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Evaluation of Suspected Environmental Contamination of the Hemlock, Michigan Area

(U.S.) Environmental Protection Agency
Chicago, IL

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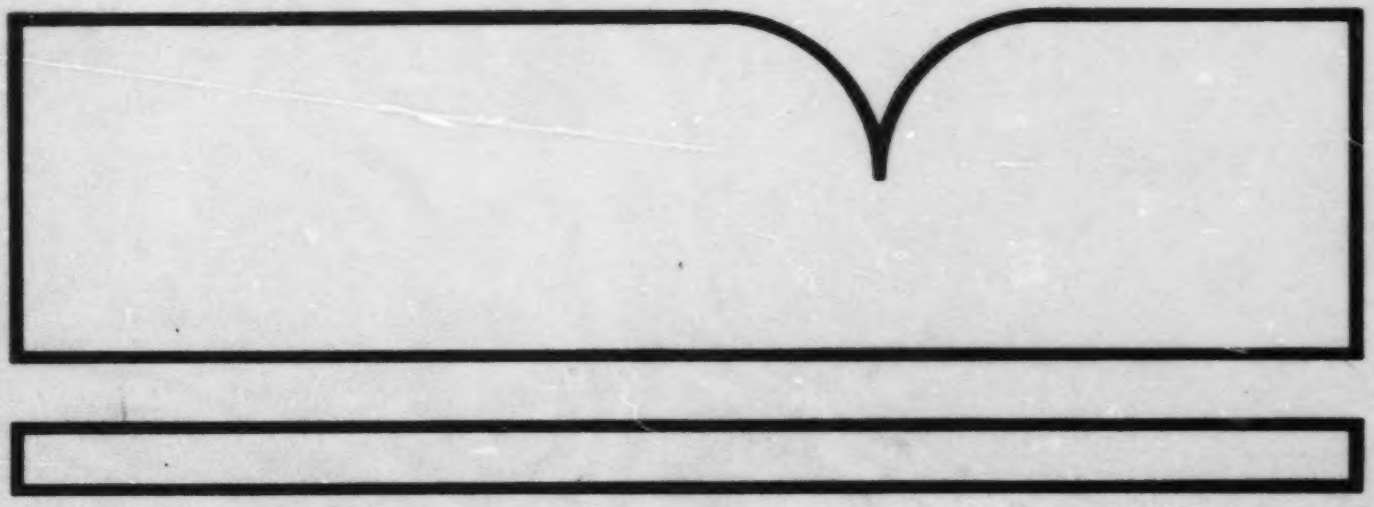

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Region V
Toxic Substances Office
230 South Dearborn Street
Chicago, Illinois 60604

September 1980

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16. ABSTRACT

The Environmental Protection Agency conducted an investigation in the Hemlock, Michigan area to determine if a chemical contamination problem existed there. This investigation was prompted by complaints of human and animal health problems in that area, which were alleged to be due to toxicants in aquifers used for drinking water supplies. Previous investigations by Michigan State agencies did not reveal a chemical contamination problem. In this study approximately ninety samples, including water, soil, animal tissues, and household dust samples, were analyzed for a wide variety of parameters. Tests conducted on the samples included arsenic, cadmium, lead, bromide, chloride, PCBs, PBBs, pesticides, dioxin, and GC/MS scans for organics. No evidence of a chemical contamination problem in the Hemlock, Michigan area was found. Only one sample, a caged fish from the Tittabawasee River, downstream from Dow Chemical, contained a detectable level of dioxin. Prior studies had also found that fish from that location were contaminated.

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REGION V
TOXIC SUBSTANCES OFFICE
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SEPTEMBER 1980

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Executive Summary

Background

Numerous complaints of human and domestic animal health problems in the Hemlock, Michigan area have been reported to various governmental agencies since 1977. Some area residents have attributed these health problems to chemical contamination of drinking water supplies. One concern of the residents was that groundwater used for drinking might be contaminated due to the presence of brine wells and a reinjection system operated by Dow Chemical Company in the vicinity of Hemlock.

PREVIOUS INVESTIGATIONS

From 1977 to 1979, the following investigations were conducted by Saginaw County and Michigan State agencies:

* Michigan Department of Agriculture and Michigan State University analyzed environmental and animal tissue samples for the presence of nine contaminants. No evidence of environmental contamination was found.

* Michigan Department of Public Health and Saginaw County Health Department analyzed well water samples for significant levels of 27 parameters and several pesticides, and examined the construction of four private wells for compliance with state regulations. No contaminants were present at levels which could be associated with the alleged health effects. The well construction was determined to be adequate and in compliance with state regulations for private wells.

* Michigan Department of Natural Resources conducted a comprehensive groundwater quality investigation in Hemlock, which included laboratory testing of water samples for additional parameters, static bioassay tests and field

surveys. These analyses did not indicate any chemical contamination of the water other than the presence of sodium chloride (salt) in high enough concentrations to affect the taste of the water.

* Michigan Department of Public Health and Saginaw County Health Department conducted an epidemiological study to compare the frequency of health complaints in Hemlock with that of a neighboring locality. Although this study showed a greater frequency of reported health complaints in the Hemlock area than in the control area, the investigation was unable to establish a link between the complaints and private well water supplies.

EPA INVESTIGATION

In July 1979, the United States Environmental Protection Agency (EPA) was asked to conduct additional investigations into the possibility of environmental contamination in the Hemlock, Michigan area. This report describes the results of that investigation. A concurrent investigation of the alleged Hemlock health problems, conducted by the Center for Disease Control, is described in a separate report.

EPA initiated its investigation with a field reconnaisance and the collection of environmental and animal tissue samples which included:

* 15 water samples from 12 residential sites
* 17 soil samples from 9 residential sites
* Dust samples from 7 vacuum cleaners and 2 furnace filters
* 2 well sediment and 1 septic tank sludge sample
* Samples from the municipal water supply
* Samples from the municipal sewage treatment facility
* Fish samples from 3 Hemlock area creeks and the Tittabawasee River
* Algae samples from one well
* 8 domestic and wild animal tissue samples

The environmental samples were analyzed for numerous parameters including: arsenic, cadmium, lead, calcium, sodium, bromide, chloride, fluoride, iodide, pesticides, PCBs, PPBs, dioxin, and various other organic chemicals. A gas chromatograph/mass spectrometer scan, which has the capability of identifying virtually an unlimited number of organic compounds, was run on the samples to detect the presence of organic compounds that could not be detected by any specific test. Approximately 1500 analyses were conducted on these samples. All analyses were conducted with current state-of-the-art techniques, using the best technology available at the time of the study.

Evidence of chemical contamination of the environment was not found other than elevated levels of sodium chloride (the principal component of table salt), which can affect the taste of the water. It is believed that ingestion of high levels of sodium may be correlated with high blood pressure in some individuals susceptible to hypertension and may be a risk to persons with heart or kidney disease. Hemlock area residents who had been drinking water with elevated sodium concentrations and who might be on sodium restricted diets have been encouraged to contact their physicians about the sodium level in their water.

The concentrations of heavy metals and other contaminants for which health-based standards exist, were below U.S. EPA's maximum contaminant levels for drinking water.

Methylene chloride, a solvent commonly used in laboratories, was found in several water samples including the control sample. The quality control data indicate that the presence of methylene chloride was due to sample contamination after the sample was collected, rather than contamination of the water supplies. Subsequent sampling indicated the absence of methylene chloride in the water.

The soil, sediment, sludge, and dust samples were found to contain several naturally occurring organic compounds. In addition, traces of several phthalates, a common component of plastic was found in several samples. The presence of phthalates was not considered to be indicative of an environmental contamination problem because of the widespread use of this chemical in paints, varnishes, rust preventatives, adhesives, cleaning agents, floorwaxes, and plastics.

Traces of other compounds, which have been widely used in consumer products were found in some of the household dust samples.

Numerous samples were analyzed for dioxin to determine if the area might be contaminated with that extremely toxic compound. Dioxin was not found in any samples taken from the Hemlock area. The presence of dioxin could only be confirmed in a caged fish taken from the Tittabawassee River downstream from the Dow Chemical Company, a waterway known to be contaminated with dioxin.

Thirty-day fish bioconcentration studies were conducted in two water supplies to test for the presence of chemicals that could bioaccumulate. The results of these studies do not indicate that the water supplies were contaminated with chemicals.

Data on Dow Chemical Company's brine system were evaluated to determine if its brine reinjection system could contaminate aquifers used for drinking water. This study did not find evidence that these wells could be responsible for cross-contamination between geological formations.

In summary, the EPA has performed a comprehensive study to determine if chemical contamination had occurred in the Hemlock, Michigan area. A wide variety of environmental samples were analyzed for the presence of an extensive number of possible contaminants. No evidence of a chemical contamination problem in Hemlock, Michigan was found.

II. INTRODUCTION

Beginning in the fall of 1977, public agencies were receiving reports of human and animal health problems in the Hemlock, Michigan area. Some residents of Hemlock believed their health problems were caused by drinking groundwater contaminated with chemicals. Some claimed, specifically, that chemical contamination had resulted from Dow Chemical Company's operation of brine wells and reinjection lines located throughout the area.

For over twenty years, Dow has pumped naturally occurring brine, located approximately 3,000 feet below ground level, up to the surface. The brine is then carried through a network of buried pipes to the Dow plant site in Midland, fourteen miles north of Hemlock. Dow reports that after salts and minerals are removed from the brine, it is returned to the underground formations by injection wells. Residents' claims of contamination were based upon the theory that chemical wastes could have contaminated the brine during processing and that operation of the injection wells or occasional leaks occurring in the buried lines may have caused chemical contamination of upper-lying aquifers used for drinking water supplies.

Between 1977 and 1979, a series of investigations were conducted by the Saginaw County Health Department and several Michigan State agencies. These agencies were unable to either identify contaminants in the water supplies or correlate the use of private well water with health complaints in the Hemlock area.

In 1979 the U.S. Environmental Protection Agency (EPA) was requested to further investigate the possibility of water contamination and to determine the possibility of other chemical contamination in the Hemlock area. To accomplish this, samples were collected from selected residential sites in the area. Water, residues from water stills, household dusts, well sediments, garden soils, and uncultivated soils were among the samples collected. Tissue samples from domestic and wild

animals in the Hemlock area were also taken. To identify chemical contaminants which may have been present in the spent brine, various samples were collected from the brine wells and lines, and from soil which may have been previously subject to brine spills.

Extensive field studies, laboratory analyses, including tests for dioxin, and bioconcentration studies were conducted. The Dow brine wells and reinjection system were evaluated for possible cross-contamination between geological formations. The results of these studies are presented in the following pages.

In conjunction with EPA's study, the Center for Disease Control (CDC) conducted an investigation of human health problems in the area. Representatives from CDC evaluated the extent of the human health problems reported in the area to determine if the occurrence of health problems was higher than expected. Results from the CDC investigation will be presented in a separate report.

III. PREVIOUS INVESTIGATIONS CONDUCTED BY MICHIGAN STATE AND LOCAL AGENCIES

The initial investigation of the Hemlock situation began in October 1977 after a resident of the Hemlock area reported a high incidence of health problems in her livestock. At this time a variety of samples and whole specimens of livestock were submitted to the Michigan Department of Agriculture (MDA) for analysis and examination. The Michigan Department of Agriculture Laboratory Division, with assistance from the Animal/Health Diagnostic Laboratory of Michigan State University (MSU), conducted autopsies and field investigations to determine the cause of the livestock's problems. Between November 1977 and April 1978, these laboratories also analyzed samples of well water, raw milk, animal feed, and various animal tissues and organs.

The samples were analyzed for the following parameters:

1. arsenic
2. lead
3. mercury
4. copper
5. nitrates
6. fluoride
7. PCBs
8. PBBs
9. pesticides

This initial investigation concluded that the animal health effects were not due to exposure to excessive levels of these nine parameters. Rather, the health problems were attributed to chronic mastitis of the herd. Evidence was not found that indicated environmental contamination.

A second investigation was initiated in mid-1978, when residents of the Hemlock area expressed the additional concern that adverse human health effects might be associated with environmental contaminants in this area. The residents were especially concerned about the Dow Chemical Company's operation of brine reinjection wells in the Hemlock area. Some residents of that area believed that toxic chemicals were entering this system from the Dow plant and contaminating the groundwater used for drinking water supplies. To investigate these reports,

the Saginaw County Health Department and the Michigan Department of Public Health, Division of Water Supply, collected water samples from the Hemlock area and examined the construction of four private wells which were suspected of being contaminated. The construction of these wells was determined to be adequate and in compliance with the Michigan State regulations. Tests were performed for twenty-seven parameters in the water samples. All parameters were at levels which could not be associated with the alleged health effects. The parameters were:

1. hardness ($CaCO_3$)
2. fluoride
3. chloride
4. nitrate
5. sodium
6. potassium
7. calcium
8. magnesium
9. zinc
10. bicarbonate
11. carbonate
12. sulfate
13. total solids
14. pH
15. conductance
16. iron
17. manganese
18. copper
19. zinc
20. cadmium
21. lead
22. silver
23. arsenic
24. barium
25. selenium
26. mercury
27. chromium

In addition, the private wells which were potentially subject to agricultural runoff were tested for some common pesticides (p,p'DDT; p,p'DDE; okp'DDT). The results of this investigation, completed in the early part of 1978, did not indicate environmental contamination of the water which could be linked to the reported human and animal health effects.

Because some of the area residents desired more extensive testing and research, they obtained the services of two independent laboratories to analyze further for contaminants. These residents and their representatives presented results of a water sample analysis at a meeting in October 1978, in Lansing, Michigan, with representatives of the Michigan Department of Natural Resources (MDNR), Water Quality Division, and representatives from other Michigan State agencies. The analysis indicated the presence of four organic compounds in the sample: diethyl ether, 1,1,2-trichlorotrifluoroethane, toluene, and trichloroethylene. The presence of these chemicals was based on a gas chromatograph/mass spectrometer (GC/MS) analysis for purgeable hydrocarbons in the sample.

A review of this data indicates that there was no quality assurance program associated with these analyses. That is, there were no quality control samples shipped or analyzed to insure that contaminants were not present in the sampling bottles themselves, or that contamination did not occur during shipment and analysis of the samples. Because of the lack of quality assurance data and due to the fact that the contaminants detected are commonly used solvents in the analytical laboratory, it is impossible to conclude that these results demonstrate chemical contamination of the sampled groundwater.

To determine if, in fact, the groundwater was contaminated, the MDNR conducted a water quality investigation in the Hemlock area (Investigation of Groundwater Quality in the Hemlock Area of Saginaw County, MDNR, April, 1979). This investigation involved water sampling and analysis, surveys to identify potential sources of groundwater contamination, determination of hydrogeological factors which might influence groundwater quality, and a static bioassay study for general toxicity. MDNR tested for the following parameters in the water samples:

"1. Diethyl ether, toluene, freon, and trichloroethylene, the substances identified. . . as being in one sample from" a private well.
"2. Thirty-nine chemicals listed on the Critical Materials Register, (the 1978 list or a previous register). Thirty-four of these thirty-nine chemicals are reported to be used or produced at the Dow Chemical facility in Midland.
3. The presence of organic chemicals using gas chromatography with as many as three different GC scans per sample.
4. Several inorganic chemicals including heavy metals and salts.
5. General water quality parameters.
6. Total and fecal coliform." (id.at, p. 9)

The results from the analyses did not indicate chemical contamination of the water. However, some groundwater sources contained high salt (sodium chloride) concentrations. The concentrations were sufficiently high to affect the taste of the water.

In addition, the MDNR used a static bioassay study to determine the general toxicity of the water. The bioassay involved exposing Daphnia magna, an aquatic

invertebrate, to water from the test locations under specific conditions and monitoring the Daphnia for toxicological effects. The bioassay results were inconclusive since the results neither supported or eliminated the possibility of water contamination.

The MDNR study also included a search for localities where groundwater contamination could potentially occur. Neither map and file inspections nor site visits by MDNR staff indicated any potential contamination sites. The study indicated that factors such as past coal and oil exploration practices or some natural hydrogeological conditions may affect groundwater quality; however, it appeared unlikely that any contamination had resulted from natural or artificial sources located in the deep formations from which brine was extracted. Hydrogeologic factors which were believed to influence the Hemlock area aquifiers included naturally occurring salts located in the upper bedrock formations.

The Michigan Department of Public Health (MDPH) and the Saginaw County Health Department conducted an epidemiological study (MDPH, 1979) to determine the significance of the alleged human health problems in the Hemlock area. This study was based on information obtained through interviewing sample populations in the northern half of Fremont Township and the southern half of Richland Township. A total of 88 households representing 303 residents responded. A comparison population was selected from the Blumfield Township, located in the northeast section of Saginaw County. Seventy-four households, representing 263 residents in this area were interviewed.

The study found more health complaints in the Hemlock area than in the comparison area. Health problems most frequently reported in the Hemlock area included:

1.) skin rashes
2.) numbness
3.) arthritis
4.) injuries
5.) dizziness
6.) arm, leg, and lower back pains
7.) visual problems
8.) nausea
9.) urine sugar
10.) thyroid problems
11.) strokes.

Differences in reported health complaints could not be attributed to differences in age or sex between the two areas. Occupational or agricultural exposure to chemicals and the use of private well water supplies were also considered in the epidemiological study, but these factors were not associated with differences in the incidence of health complaints.

In summary, investigations by the Saginaw County Health Department, MDA, MDPH, and MDNR did not produce evidence of groundwater contamination or indicate the presence of toxic chemicals in the environment which would cause animal or human health problems.

IV. EPA INVESTIGATION

A. Introduction

In July 1979, EPA was requested to assist the State of Michigan by conducting a more extensive investigation to assess whether a contamination problem existed in Hemlock and the surrounding area. In response to that request, Region V staff members met with representatives of the MDA, MDPH, MDNR, and the center for Disease Control to consider plans for further evaluation of the Hemlock problem.

In September 1979, EPA and MDNR representatives jointly conducted a reconnaissance survey of various sampling sites and homes in the Hemlock area. During the period from October 1979, to February 1980, representatives from these agencies collected a variety of environmental samples including water, soil, dust, sediment, and sludge samples. These samples were collected from 12 residential sites, the public water and wastewater systems of Hemlock, the Dow brine production and injection system, and other selected locations near the Dow brine system. Tissue samples from domestic and wild animals were also collected during this time.

During October, a 30 day fish bioconcentration study was conducted using private well water from one of the residential sites. A similar bioconcentration study was conducted in May 1980 using water from the Hemlock public supply. Fish tissue samples were collected from these studies and analyzed for the presence of low-level contaminants which would accumulate in the fish but would not be detected by analyses of the water.

All samples were analyzed using current state-of-the-art methodology. Documentation of methods used are available through the Toxic Substances Office, Region V, U.S. EPA, Chicago, Illinois.

To insure the reliability of the data generated, a rigid quality assurance program was conducted for all samples. Numerous duplicate samples were taken, and blanks

(samples which contain no contaminants) were prepared and analyzed. Spiked water, sediment and tissue samples from U.S. EPA, Region V's Central Regional Laboratory were shipped to and analyzed by the analytical laboratory. Additionally, in those cases where questions were raised, such as in some of the volatile organic samples, sites were resampled.

The environmental and tissue samples were analyzed for a wide variety of parameters including:

1) Arsenic
2) Cadmium
3) Lead
4) Calcium
5) Sodium
6) Bromide
7) Chloride
8) Fluoride
9) Iodide
10) Purgeable organic compounds
11) Nonpurgeable organic compounds
12) Pesticides
13) Polychlorinated biphenyls
14) Polybrominated biphenyls

These samples were also "scanned" for other organic chemical compounds using gas chromatography coupled with mass spectrometry (GC/MS).

Tissue samples and selected environmental samples were also analyzed for 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin, commonly known as dioxin, for a number of reasons. First, dioxin is a highly toxic chemical. Secondly, Dow Chemical produces certain pesticides, including 2,4,5-T, silvex, and trichlorophenol at their facility in Midland, fourteen miles north of Hemlock. Dioxin may be formed as a by-product during the production of these chemicals (Federal Register, August 2, 1978). And, thirdly, dioxin has been detected in fish collected from the Tittabawasee, Saginaw, and Grand Rivers in Michigan, in 1978 (EPA study, 1978).

In addition to collecting and analyzing samples from the Hemlock area, EPA staff evaluated the design and construction methods used by Dow Chemical Company for their brine production and injection wells. Documents and information supplied by Dow were reviewed to assess whether the construction of these wells would allow contamination of upper-lying aquifers.

B. Environmental Samples from Residential Sites

Samples were collected from 12 residential sites in the Hemlock area. A map which is located on page 15, designates the location of these residential sites and identifies them by site number. Table 1, page 16, gives the number and types of samples collected from each of these sites.

1. Water

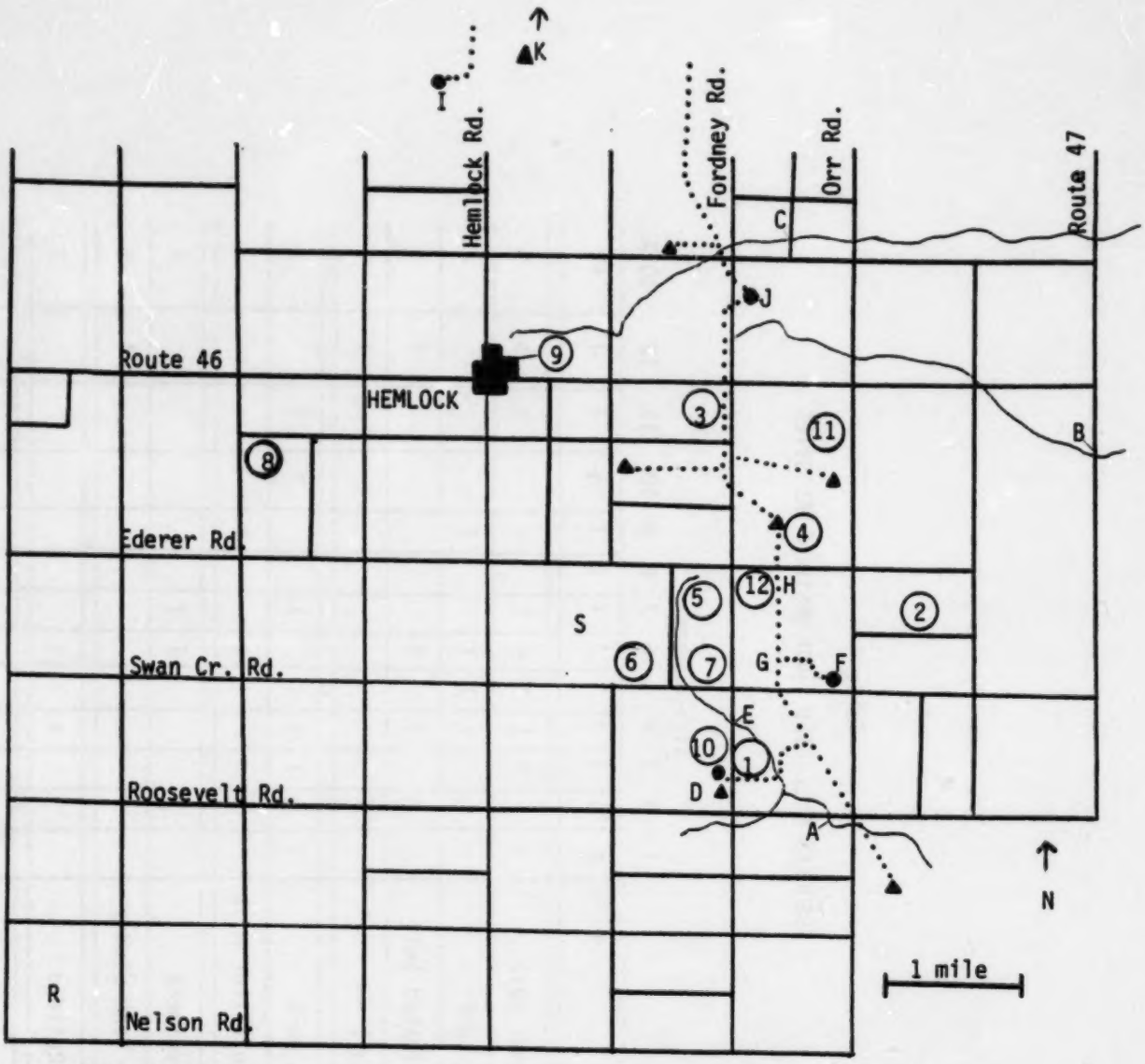
A total of 15 water samples were collected from the 12 residential sites. All samples were analyzed for nine inorganic chemicals. Results from the analysis of these samples are given in Table 2, page 17. In general, these chemicals were at levels which are not known to be harmful to health.

The quality of the water did appear to be affected at some locations by sodium chloride. This condition is probably due to natural causes since wells deeper than the glacial drift layer in this area typically contain saline water (Michigan Water Resources Commission, 1963). According to U.S. Geological Survey geologist, Floyd Twenter (personal communication, July 9, 1980), salty water is frequently found in aquifers of rock formations below the glacial drift layer and in nearby aquifers. Since the depth of the glacial drift in this area ranges from 115 to 250 feet (MDNR, 1979), wells near or below the depth of the glacial drift for a specific area, would tend to be salty due to the natural conditions of the aquifer. What effect, if any, other factors have had in contributing to the saline condition, especially in wells of shallow depth, can not be determined with available information.

Dr. Renate Kimbrough, a toxicologist at the Center for Disease Control in Atlanta, (personal communication July 5, 1980) recommended that well water at site number 7 should not be used for drinking because of the high sodium level. Consuming two liters of water each day (a typical amount for adults) from this water supply and ingesting salt from food would result in the ingestion of roughly

FIGURE 1

MAP OF HEMLOCK AREA AND SAMPLING SITES



..... Brine line
● Brine injection well
▲ Brine production well

(1)-(12) Private Residences (9 is located within Hemlock)

A - Fish collection point in Marsh Creek
B - Fish collection point in Williams Creek
C - Fish collection point in McClellan Run
D - Brine injection well
E - Smith Drain (collection point of creek bed sediment)
F - Brine injection well
G - Sample collection point from brine line
H - Sandpit near brine line
I - Brine injection well
J - Brine injection well
K - Brine production well
R - Location from which the deer was taken
S - Location from which the squirrel was taken

Table 1

SAMPLES COLLECTED FROM RESIDENTIAL SITES

	Site Number												
	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Water	3	1	1	1	1	1	1	2	1	1	1	1	15
Downspout Soil	1		1	1	1	1	1		1		1	1	9
Garden Soil				1	1	1			1				4
Uncultivated Soil				1		1						1	3
Sump Soil												1	1
Vacuum Dust	1		1	1	1		1			1	1		7
Furnace Filter Dust						1			1				2
Well Sediment						1	1						2
Septic Tank Sludge												1	1
Still Residue				1		1							2
TOTAL	5	1	3	6	4	7	4	2	4	2	3	5	46

* - Number of samples

Table 2

RESULTS OF ANALYSES OF WATER SAMPLES FROM RESIDENTIAL SITES

	Site Number														
Parameters	1**	1	1	2	3	4	5	6	7	8**	8	9	10	11	12
Arsenic (ppb)	8	7	19	6	6.5	5	6	5	5	<5	11	6	9	<5	<5
Cadmium (ppb)	0.6	1	1	1	0.4	0.4	0.7	0.6	1.2	<1	<1	0.2	0.7	0.13	0.13
Lead (ppb)	5	2	2	5	18	1	3	1	6	3	3	3	4.5	1.2	0.95
Calcium (ppm)	106	100	96	146	91	137	29	52	73	106	100	104	119	160	140
Sodium (ppm)	126	250	220	400	97	245	450	405	1,175	49	49	88	134	500	360
Bromide (ppm)	0.28	0.6	0.8	<.01	<0.01	0.07	0.41	0.7	0.82	<.01	<.01	<.01	<.01	<.01	<.01
Chloride (ppm)	135	121	123	458	50	276	343	332	1.550	40	19	53	128	582	507
Fluoride (ppm)	0.8	0.8	0.7	0.8	0.7	0.51	2	<0.1	0.7	1.2	0.6	0.6	0.7	0.8	0.6
Iodide (ppm)	.003	.002	.003	.008	.004	0.01	.0007	.003	.014	.003	.004	.002	.002	.002	.007
Purgeable Organics	ND							ND	ND				ND		
methylene chloride (ppb)		19*	22*	26*	30*		9*			16*	4*	16*		17*	
toluene (ppb)						6*						5*			9*
Nonpurgeable Organics	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND	ND
Bis(2-ethylhexyl) phthalate (ppb)										18*					
Diethyl phthalate (ppb)										11*					
Pesticides	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PBBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tentatively Identified Compounds		ND	ND	ND	ND	ND	ND				ND		ND	ND	ND
cholestanol	X											X			
hexadecanol	X								X	X		X			
9-octadecen-1-ol	X							X				X			

ppm - parts per million.
ppb - parts per billion.
< - Actual value, if present, is less than stated value.
ND - Not detected in the sample.
* - Value may be attributed to laboratory contamination.
** - Three samples were analyzed from site number 1; two samples were analyzed from site number 8.
X - Indicates the compound was tentatively identified in the sample.

twice the recommended daily salt intake. Based on personal communication on July 23, 1980 with Dr. Stephen Hessl (Head, Section of Occupational Medicine at Cook County Hospital), increased sodium intake may be detrimental to persons suffering from various kidney and heart ailments and hypertension. But, according to Dr. Hessl, there is no evidence that a normal, healthy person would develop health problems from the sodium levels present in the water samples.

Analysis for organic compounds indicated the presence of methylene chloride, toluene and two types of phthalates in some of the water samples. The presence of these compounds appeared to be due to laboratory contamination, based on the control samples and the fact that these compounds were not found when the water supplies were resampled.

The GC/MS scan identified three organic compounds, which are sometimes associated with fecal contamination, in five of the water samples. Fecal coliform tests, which are more reliable indicators for this type of contamination, were conducted by MDPH and MDNR on water from these locations. These tests did not indicate fecal contamination.

The following material in this section gives a more detailed evaluation of these water samples.

Arsenic levels

Arsenic levels in the water samples ranged from below detection [5 parts per billion (ppb)] to 19 ppb. All levels were below the EPA maximum contaminant level of 50 ppb.

Cadmium levels

Cadmium levels ranged from below detection (1 ppb) to 1.2 ppb and are below the EPA maximum contaminant level of 10 ppb. During the original analysis of these samples, the cadmium level for the water sample from site number 11 was reported to be 70 ppb, and from site number 12 the cadmium level was reported to be

17 ppb. Because both of these levels exceeded the EPA standard for cadmium in drinking water, the residents were advised not to drink the water until the wells were resampled. The results of the second analysis indicated that the cadmium levels in the water were normal and below the standard for both locations. Apparently a laboratory error was responsible for the higher levels reported initially. MDPH and MDNR also collected and analyzed water from these two locations to recheck the cadmium levels. Their results also indicated that the cadmium levels in these two wells were not elevated.

Lead levels

Lead levels in the water samples ranged from .95 to 18 ppb and are below the EPA standard of 50 ppb.

Calcium levels

Calcium levels ranged from 29 to 160 parts per million (ppm). There is no EPA health-related standard for calcium in drinking water. Calcium is an essential nutrient and, by being in the water, may beneficially contribute to the body's daily nutritional needs (National Research Council, 1979). Although calcium in drinking water is not harmful to health, high levels may affect water by causing it to be hard. Water containing a level of calcium ranging from 75 to 150 ppm is generally considered to be moderately hard and would affect the quality of the water by interfering with the cleaning ability of certain soaps.

Sodium levels

Levels of sodium ranged from 49 to 1,175 ppm with an average level of 293 ppm. The one extreme value of 1,175 ppm was detected in the sample from site number 7 as compared to the second-highest value of 500 ppm detected from site number 11. There is no EPA standard for sodium in drinking water; however, the American Heart Association recommends that a person on a sodium-free diet should not continually drink water containing more than 20 ppm of sodium. It is also recommended that a person on a moderately restricted sodium diet should not continually drink water

containing a sodium level greater than 270 ppm. Doctors will sometimes place people with heart, circulatory, or kidney illnesses on sodium restricted diets. Persons whose water supplies had levels of sodium above 270 ppm and who had a medical history of such illnesses were encouraged to check with their physicians to determine whether they should limit the amount of this water they drink.

Bromide levels

The bromide levels in the water samples ranged from below detection (less than 0.01 ppm) to 0.82 ppm. Bromide is seldom found in water at detectable levels other than sea water, brines, and water affected by salt formations (Sneed, et. al., 1954). The salt content in the upper bedrock formations (MDNR, 1979) appears to be the source of the bromide levels in the upper-lying aquifers. According to Dr. Renate Kimbrough (personal communication, July 7, 1980), the levels of bromide detected in the water samples are not known to cause health problems.

Chloride levels

The chloride levels ranged from 19 to 1,550 ppm with an average of 314 ppm and a median of 135 ppm. The one extreme value of 1,550 ppm was detected in the sample from site number 7. One would expect to find high sodium and high chloride levels in the same sample since high sodium and chloride levels are often associated with one another. There is no health-related standard for chloride in drinking water; however, there is an EPA secondary standard for chloride of 250 ppm. Secondary standards exist for parameters which affect the aesthetic quality of the water, such as its taste, odor, color, or appearance, rather than affect health. Many people object to a salty taste in water when chloride is above 250 ppm. In addition to affecting its taste, high chloride levels may cause plumbing to deteriorate more quickly.

Fluoride levels

The fluoride levels ranged from below detection (less than 0.1 ppm) to 2 ppm. These levels do not exceed the EPA standard of 2 ppm for that geographic area.

Iodide levels

Levels of iodide in the water samples ranged from 0.0007 to 0.01 ppm. In areas with an average iodide content in the soil, the drinking water usually contains approximately 0.001 ppm (Ermolenko, 1972). Iodide levels in water vary depending upon the location, soil and geological formations. There is no EPA standard for iodide in drinking water, and the levels measured in the water samples are not known to be harmful to health. In fact, iodide levels in water may contribute to the body's daily nutritional needs. Low-iodide waters (around .001 ppm) can provide around 1-2% of a person's daily requirements and high-iodide waters (0.018 ppm) can provide from 24 to 44% of a person's daily needs for iodide (National Research Council, 1979).

Purgeable Organics

The analysis for volatile organic compounds (purgeable organics) indicated the presence of methylene chloride and toluene, common laboratory chemicals, in several of these samples. The quality control samples, however, indicated that these results were due to contamination occurring either during the shipment of the samples from the sampling location to the laboratory or due to laboratory contamination of the samples prior to analysis. This was confirmed when new samples were analyzed and yielded negative results.

Nonpurgeable Organics

Two nonpurgeable organics, bis (2-ethylhexyl) phthalate and diethyl phthalate, were detected in one of the water samples from site number 8 at levels of 11 and 13 ppb. Phthalates are a group of compounds which are commonly found in the environment because of their extensive use in the manufacturing of plastics. Consequently, phthalates could originate from many products found in the home. If the phthalates were actually in the water at the time of sampling, their presence could be due to the use of plastic being used in the plumbing, such as in a water softening device or plastic pipes. It is also possible that contamination

of the water sample with phthalates occurred after the sample was collected. The possibility of sample contamination is supported by the analysis of a duplicate sample from site number 8 in which no phthalates were detected.

Pesticides, PCBs, PBBs

The water samples were analyzed for pesticides, PCBs (polychlorinated biphenyls) and PBBs (polybrominated biphenyls). These chemical compounds were not detected in any of the water samples at a detection limit of 1 ppb.

Tentatively Identified Compounds

In five water samples, three organic compounds (cholestanol, hexadecanol, and 9-octadecen-1-ol) were tentatively identified. These compounds are found in fecal material, and, therefore, may be indicative of fecal contamination. Based on these tentative findings, MDPH and MDNR performed fecal coliform tests on water from these locations. The fecal coliform test is a more reliable test for detecting fecal contamination. The results of the fecal coliform tests indicate that the wells were not contaminated when the tests were made.

2. Water Distillation Residue

Some residents in the Hemlock area had been distilling their water and reported that once they began this practice, their health seemed to improve. The residues from the water which remained in the distilling devices were sampled from two units used at residences numbered 4 and 6. The results from these samples are given in Table 3, on page 23.

Polychlorinated biphenyls (Arochlor-1254) were tentatively indicated in the residue from site number 4 at a level of 5.7 ppb. However, due to the low level detected, it could not be confirmed whether PCB was actually present. Its presence was indicated when analyzed by electron-capture gas chromatography (GC-EC) but it could not be detected when the sample was reanalyzed by gas chromatography coupled with mass spectrometry (GC/MS). (GC-EC can detect lower levels of chemicals than GC/MS,

Table 3

RESIDUE FROM WATER DISTILLATION

UNITS USED AT RESIDENTIAL SITES

Parameters	Site Number 4	6
Arsenic (ppb)	7	8
Cadmium (ppb)	11	13
Lead (ppb)	2	33
Calcium (ppm)	NA	NA
Sodium (ppm)	NA	NA
Bromide (ppm)	4.8	4.5
Chloride (ppm)	3820	843
Fluoride (ppm)	1.5	1.7
Iodide (ppm)	0.014	.04
Purgeable Organics	NA	NA
Nonpurgeable Organics	ND	ND
Pesticides (ppb)	ND	ND
PBBs (ppb)	ND	ND
PCBs (ppb)		ND
PCBs (Arochlor 1254)	5.7*	
Tentatively Identified Compounds	cholestanol hexadecanol	cholestanol hexadecanol 9-octadecen-1-ol

ppb - parts per billion.
ppm - parts per million.
NA - Not analyzed for in the sample.
ND - Not detected in the sample.
* - Was detected by GC/EC but could not be confirmed by GC/MS.

but is not as accurate at identifying specific chemicals.) Analysis of the water sample from this location did not show PCBs to be present in the water.

In addition, a 30-day, fish bioconcentration study using water from this location was conducted. If PCBs were present in the water, they should have accumulated in the fish tissue and would have been detected when analyzed. Since PCBs were not detected in the fish tissue samples collected from this bioconcentration study, it can be concluded that PCBs were not present in the water from this location.

Cholestanol, hexadecanol, and 9-octadecen-1-ol were tentatively identified in the residue samples. Since these compounds indicated the possibility of fecal contamination, water samples were collected and tested for fecal coliform bacteria. Results from these tests did not indicate the presence of fecal coliform.

3. Soil

Seventeen soil samples were collected from nine residential sites. These consisted of scrapings up to 2-4 inches in depth from the soil surface. Soil samples were collected below gutter downspouts to help identify atmospheric contaminants which may have been present in the air. During periods of rainfall, atmospheric contaminants would be washed out of the air with the rain and would be concentrated in the soil at these locations. The single soil sample collected near a basement sump drain was expected to contain contaminants similar to those found in soil below gutter downspouts. Garden soil samples and uncultivated soil samples were collected to determine if chemical contaminants were present in the soil itself or as a result of long-term deposition from the air, water drainage, or other routes. The laboratory results from these samples are summarized on Tables 4 and 5 on pages 25 and 26, respectively. Because of the large number of additional chemical compounds identified by the gas chromatography-mass spectrometry scan, these compounds are summarized separately in Table 6 on pages 27 and 28.

Table 4

DOWNSPOUT SOIL SAMPLES FROM RESIDENTIAL SITES

PARAMETERS (ppm)		Site Number 1	3	4	5	6	7	9	11	12
Arsenic	L (Leachable)	3.9	0.31	0.33	0.33	0.51	0.64	0.91	0.44	0.24
	T (Total)	9.0	3.2	5	0.98	1.9	5.4	3.2	6.8	1.4
Cadmium	L	0.64	0.12	0.12	0.12	1.1	0.35	0.2	0.27	0.06
	T	1.7	0.40	0.38	0.15	1.8	1.3	0.35	0.66	0.17
Lead	L	120	12	14	4	10	180	19	52	8
	T	120	20	60	7.4	100	170	30	65	18
Calcium	L	6,700	13,000	1,200	2,000	5,000	8,000	30,000	9,800	470
	T	7,100	18,000	5,200	4,700	7,200	9,700	29,000	11,500	3,600
Sodium	L	70	60	50	80	70	70	60	50	50
	T	4,300	4,400	5,400	3,700	4,700	4,900	4,800	4,800	4,700
Bromide	L	3.2	4	4.8	< 2	< 2	< 2	11	9.6	6.4
	T	< 10	< 10	310	< 10	< 40	< 10	180	< 10	< 10
Chloride	L	800	1,800	650	4,860	500	510	400	940	180
	T	4,460	1,800	670	5,000	2,000	500	400	1,000	165
Fluoride	L	12.8	20	5.6	20	3.6	6.4	8.8	3.2	26
	T	480	72	< 5	440	< 5	90	9	< 5	15
Iodide	L	0.8	0.2	0.1	0.17	0.1	<0.1	0.2	0.02	0.8
	T	< 1	< 0.1	0.3	0.25	1	<0.1	0.2	0.2	< 1
Organics			ND			ND	ND		ND	ND
Bis(2 ethylhexyl)phthalate				0.21	0.22			2		
Pyrene		0.24								
Pesticides		ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs		ND	ND	ND	ND	ND	ND	ND	ND	ND
PBBs		ND	ND	ND	ND	ND	ND	ND	ND	ND
Tentatively Identified Compounds (quantity detected)		6	9	3	4	4	1	0	4	1

ND - Not detected in the sample.
ppm - All values are expressed in parts per million.
< - Actual value, if present, is less than stated value.
Leachable - Amount extracted from the sample by dilute acid washing.
Total - Total amount in the sample (leachable plus remaining).

Table 5

GARDEN, UNCULTIVATED, AND SUMP SOIL SAMPLES FROM RESIDENTIAL SITES

Parameters (ppm)		Type of soil sample and location of samples taken by site number: GARDEN SOIL 4	GARDEN SOIL 5	GARDEN SOIL 6	GARDEN SOIL 9	UNCULTIVATED SOIL 4	UNCULTIVATED SOIL 6	UNCULTIVATED SOIL 12	SUMP SOIL 12
Arsenic	L (leachable)	1.4	1.4	1.1	1.3	2.4	0.35	0.6	0.93
	T (total)	6.2	4	5.8	6.4	3.5	1.3	3.6	2.0
Cadmium	L	0.07	0.15	0.13	0.42	0.05	0.15	0.09	0.22
	T	0.23	0.21	0.21	2.1	0.11	0.19	0.21	0.53
Lead	L	14	9	12	11	5	6.9	3	47
	T	23	23	18	28	6.9	19	17	55
Calcium	L	2,000	3,200	4,200	18,000	600	7,500	2,700	6,000
	T	4,000	6,000	5,200	27,000	1,900	11,000	5,500	6,000
Sodium	L	50	70	40	100	50	70	70	160
	T	3,600	3,000	3,700	5,700	2,900	2,100	4,000	4,400
Bromide	L	6.4	6.4	1.6	3.2	4.8	6.8	11	2.6
	T	200	<10	<10	170	<10	285	<10	<10
Chloride	L	190	500	180	660	260	1,070	1,260	270
	T	230	500	200	660	270	6,440	1,480	275
Fluoride	L	3.4	24	9.6	8	10	5.6	10	<0.8
	T	<5	25	10	110	35	5	10	<5
Iodide	L	0.1	0.01	<0.01	0.3	<0.01	0.1	0.2	0.05
	T	<0.2	<0.1	0.4	0.5	0.2	<0.5	0.1	<0.1
Organics			ND	ND	ND	ND	ND		ND
Bis(2-ethylhexyl)phthalate		1.5						1.1	
Pesticides		ND	ND	ND	ND	ND	ND	ND	ND
PCBs		ND	ND	ND	ND	ND	ND	ND	ND
PBBs		ND	ND	ND	ND	ND	ND	ND	ND
Tentatively Identified Compounds (quantity detected)		6	3	3	2	1	7	4	4

(ppm) - All values are expressed in parts per million.
< - Actual value, if present, is less than stated value.
Leachable - Amount extracted from the sample by dilute acid washing.
Total - Total amount in the sample (leachable plus remaining).
ND - Not detected in the sample.

Table 6

SOIL, DUST, SEDIMENT, AND SLUDGE SAMPLES FROM RESIDENTIAL SITES
(CHEMICAL COMPOUNDS TENTATIVELY IDENTIFIED BY A GAS CHROMATOGRAPHY-MASS SPECTROMETRY SCAN)

Type of Sample and Site Number

CHEMICAL COMPOUNDS		Downspout Soil 1	3	4	5	6	7	11	12	Garden Soil 4	5	6	9	Uncultivated Soil 4	6	12	Sump Soil 12	Vacuum Dust 1	3	4	5	7	10	11	Furnace Dust 6	9	Well Sediment 6	7	Septic Tank Sludge 12
ALCOHOLS	2-ethylhexan-1-ol																	X								X			
	isoctanol																								X	X			
	hexadecanol		X					X									X				X							
	2-methyl-1-hexadecanol														X														
	heptadecanol			X	X			X		X	X			X													X	X	
	nonadecanol		X				X	X		X																			
	eicosanol									X																		X	
ALDEHYDES	nonanal																	X	X			X							
	tetradecanal														X														
	octadecanal		X												X														
	4-hydroxy-3-methoxy benzaldehyde	X																											
ALKANES	3,3-dimethylhexane			X						X																			
	2-methylnonane				X																					X			
	2,6,11,trimethyldodecane																									X			
	octadecane		X									X							X							X			
	eicosane	X																				X							
	tricosane																	X											
	pentacosane																	X		X	X			X					
	hexacosane																			X									
	octacosane																							X					
	pentatriacontane																		X										
	hexatriacontane	X	X					X		X					X			X			X					X			
ALKENES	1,11-dodecadiene									X																			
	hexadecene								X				X		X	X	X												
CARBOXYLIC ACIDS	pentanoic acid																	X											
	hexanoic acid																			X	X	X		X	X			X	
	octanoic acid	X	X															X	X	X		X		X		X			
	nonanoic acid																	X		X	X	X		X	X	X			
	decanoic acid																	X		X	X	X		X	X	X			
	8-methyldecanoic acid, methyl ester														X														

X - Indicates the compound was tentatively identified in the sample.

Table 6

(continued)

CHEMICAL COMPOUNDS		Type of Sample and Site Number: Downspout Soil 1	3	4	5	6	7	11	12	Garden Soil 4	5	6	9	Uncultivated Soil 4	6	12	Sump Soil 12	Vacuum Dust 1	3	4	5	7	10	11	Furnace Dust 6	9	Well Sediment 6	7	Septic Tank Sludge 12
CARBOXYLIC ACIDS(cont.)	dodecanoic acid																	X	X	X	X	X	X	X	X	X			X
	tetradecanoic acid					X												X	X	X	X	X	X	X	X	X			
	tetradecanoic acid, methyl ester																	X	X	X	X	X		X					X
	pentadecanoic acid																	X	X	X	X	X		X					
	hexadecanoic acid	X	X	X	X	X					X	X	X			X		X	X	X	X		X	X	X	X	X	X	X
	methylheptadecanoic acid, methyl ester																												
	octadecanoic acid															X													X
	eicosanoic acid, methyl ester																												X
	heneicosanoic acid, methyl ester					X					X				X													X	X
KETONES	trimethylpentadean-2-one	X																											
	1,7,7,trimethyl-bicyclo(2.2.1)heptan-2-one																X												
OTHER ORGANIC COMPOUNDS	1,1 dodecanediol diacetate																X												
	hexadecanol acetate																												X
	benzeneacetic acid				X	X					X																		
	cholesta-diene															X													
	dioctyl ether		X																										
	4-methylphenol																												X
	biphenyl																	X			X								
	bis(2-methylpropyl) phthalate		X																										
	phthalic acid																		X										
TOTAL COMPOUNDS DETECTED IN EACH SAMPLE		6	9	3	4	4	1	4	1	6	3	3	2	1	7	4	4	13	10	10	9	11	3	10	7	11	3	4	7

X - Indicates the compound was tentatively identified in the sample.

Inorganic Elements

Leachable and total levels of inorganics were determined during the analyses of the samples. The leachable value of the sample was obtained by mixing the sample with a weak acid, in order to extract the soluble portion of the sample for separate analysis. The total value given represents the leachable portion plus the amount which remained in the sample after the first extraction. In a few instances, the total value was reported to be slightly less than the leachable value. In these instances, the leachable value was actually the total, with the slight differences caused by acceptable experimental variation during the analyses. The evaluation of the levels of inorganics in the samples was based on the total levels which were detected in the samples.

The exact composition and characteristics of soil in a given location depend on many factors such as climate, landscape, and the rocks and minerals present in the area from which the soil was derived (Townsend, 1973). For this reason, the levels of the inorganic elements will vary for each area. When evaluating the levels detected, broad ranges rather than averages must be used in assessing whether the levels detected indicate an excessive amount.

For the inorganic metals (arsenic, cadmium, and lead), the levels detected in the samples from the Hemlock area are comparable to levels which have been detected in soil from other areas. Natural background levels of arsenic in soil range from 1-70 ppm (Bear, 1964) with an average of 6 ppm (Lisk, 1972). In other locations, higher concentrations up to 158 ppm have been detected because of the addition of arsenic to the soil (Carey, et. al., 1980). The arsenic levels in Hemlock area samples ranged from 0.98 to 9 ppm which are typical of naturally occurring levels.

The cadmium levels detected in the samples ranged from 0.11 to 2.1 ppm. Cadmium generally ranges from 0.01 to 7 ppm in soil (Bohn, et. al., 1979). Background cadmium levels in rural soils normally average around 0.1 ppm, while some agricultural land and soils in urban areas have concentrations around 1.0 ppm or higher (EPA Health Assessment Document for Cadmium, 1979). Except for one sample, the cadmium levels of the garden and uncultivated soil samples were generally at 0.2 ppm, an average background level. The one higher value of 2.1 ppm was detected in garden soil from a home (site number 9) located in the town of Hemlock. The higher cadmium level could have resulted from several factors including the use of phosphate fertilizers in this area, and from other anthropogenic sources which involve the burning of coal, oil, or gasoline (Lisk, 1972). The downspout soil samples contained slightly higher levels of cadmium. This would be expected since airborne cadmium which was deposited on the roof would accumulate at these locations.

Lead content in soil is often more variable than levels of arsenic and cadmium. Lead occurs naturally in soils at concentrations from 10 to 20 ppm (Swaine, 1955); however, because of the presence of lead in such items as gasoline and paint, levels are detected in soil ranging from 20 to 1,060 ppm (Solomon, Hartford, 1976). Lead levels detected in the Hemlock samples ranged from 6.9 to 170 ppm and fall in the range of expected values. The higher levels were detected in the downspout soil samples and are probably due to a lead-based paint which may have been used on these houses. These findings are in agreement with the results of Solomon and Hartford (1976) who reported that the highest residential lead levels were in soil samples collected next to houses and other painted structures.

Calcium levels in soil samples ranged from 1,900-29,000 ppm which are common levels. Calcium is a major component of soil. In areas, which have been

affected by limestone deposits, calcium may be at levels of 250,000 ppm, which is equivalent to 25% of the weight of the soil (Hausenbuiller, 1972). More typical values characteristic of loam, silt, and clay soils in the humid and temperate regions range from 10,000-20,000 ppm (Bear, 1955).

The measured sodium levels (2,100-5,700 ppm) also appear to be typical. Bear (1964) reports that the sodium content of many soils ranges from 1,000 to 10,000 ppm, and Vinogradov (1972) reports the average sodium content to be around 7,000 ppm.

Levels of bromide which are found in soils vary, depending on the organic content of the soil (Ermolenko, 1972). Most bromide in soil originates from the soil-forming rocks. In the elemental state it is usually present in only trace amounts since it is easily leached from the soil (Hesse, 1971). However, bromide tends to accumulate in organic soils because of the presence of humic substances which bind bromide. Therefore, bromide levels depend more on the amount of humic substances in a particular area than the type of soil present. Ermolenko (1972) reports that sandy soils may contain only 0.1-1 ppm bromide as compared to humus-rich soils, such as peats, which may contain 60-600 ppm of bromide. The bromides detected in the soil samples ranged from below detection (less than 10 ppm) to 310 ppm.

Chlorides were detected in the soil samples at levels from 165 to 6,440 ppm. The usual range of chloride levels is 50-500 ppm; however, higher levels are found in soils with accumulated salts (Hausenbuiller, 1972). The soil samples collected from the gardens and uncultivated areas have more typical levels of chloride, averaging around 550 ppm. One exception to this is the uncultivated soil sample from site number 4 with a concentration of 6,440 ppm. This sample was collected from a field located near a dirt road. In the past, brine was

sprayed on dirt roads in the county for dust control. This practice may be a contributing factor in the high chloride levels in this and similar areas. The higher chloride levels of the soils under the downspouts would most likely be due to chlorides which have been deposited from the atmosphere. A common source of atmospheric chlorides is from the combustion of fossil fuels such as coal and oil which contain varying amounts of chlorine (Eliassen, 1959).

Fluoride, another variable component of the soil, was detected at levels ranging from below detection (less than 5 ppm) to 480 ppm. These levels appear normal since fluoride levels typically range from 10 to 1000 ppm (Bear, 1964). Fluoride is a typical component of certain minerals common in soil.

Iodide levels detected in the samples (less than 0.1-1 ppm) were below levels typically found in soil. Bear (1964) reports the normal range for iodide in soils to be 0.6 to 8.0 ppm.

Organic Compounds

Bis (2-ethylhexyl) phthalate was detected in five of the soil samples. This compound is widely distributed in the environment because of its widespread use in products such as paints, varnishes, and rust preventatives (Initial Report of the TSCA Interagency Testing Committtee, 1978). The widespread use of this chemical compound may be the cause of its presence in the soil samples.

Pyrene, another organic compound, was detected in downspout soil from site number 1. Pyrene belongs to a class of compounds known as polycyclic aromatic hydrocarbons and is most often found as a by-product of incomplete combustion of organic matter (Hoffmann, Wynder, 1968). The most likely source of pyrene at this location would be from the wood-burning stove used in the

house. The smoke produced from the stove would contain pyrene and similar compounds and would distribute these compounds in the vicinity of the house.

Tentatively Identified Compounds

Thirty additional compounds were tentatively identified in various soil samples by the GC/MS scan and are listed in Table 6, on pages 27 and 28. The types of compounds identified are those which are commonly found in soil or would be expected to be present in soil samples. Chemical compounds which would indicate a contamination problem were not detected in these samples.

Most of these compounds probably originated from living organisms, either directly from the organisms or from the natural breakdown of their components or by-products. For example, dead plant tissue will undergo a complex decomposition process by which its components will be chemically changed or broken down in the soil. Buckman and Brady (1960) outlined the stages of decomposition during which the original compounds in plant tissue (eg., oils, fats, resins, starches, sugars, proteins) will eventually become the complex organic material in soil known as humus. During this decomposition, various compounds will be formed and decomposed. These compounds could account for some of the alcohols, aldehydes, carboxylic acids, and other types of compounds in the soil.

Small microorganisms themselves, such as bacteria, would also contribute to the presence of these organic compounds. Average soils may contain from 10 - 100 million bacteria per gram of soil (Allison, 1973). These bacteria contain many biochemical compounds such as the lipids in which a variety of carboxylic acids have been identified (Shaw, 1974).

Several of these compounds may have originated from a single natural compound present in the soil. It has been determined that microbial activity on a

specific organic compound will yield a variety of degradation products. For example, carboxylic acids may undergo the following reactions when being decomposed by microorganisms (Meikle, 1972):

1) shortening of the carbon chain by two carbons through beta-oxidation which would produce a different carboxylic acid.
2) removal of the carboxyl group producing an alkane or alkene.
3) replacement of the carboxyl group by a hydroxy group resulting in an alcohol.

Consequently, the breakdown of hexadecanoic acid, for instance, may produce tetradecanoic acid, pentadecane, hexadecanol, and other products. Similar general reactions are known to occur with alkanes, alkenes, ketones, esters, and other types of organic compounds.

4. Dust

Seven vacuum cleaner dust samples and two furnace filter dust samples were collected from nine of the residential sites. These samples were collected to identify contaminants which may have been deposited within homes from outside sources. The results of the analyses of these samples are contained in Table 7, on page 35.

The arsenic content of these dusts do not appear high compared to the results from one study in which 61 household dust samples were analyzed for arsenic (Klemmer, et. al., 1975). Klemmer found levels of arsenic ranging from 1.1 to 1,080 ppm. The higher values were found in homes which had been treated for termites or contained lumber which had been treated with certain preservatives. The arsenic levels in the Hemlock samples ranged from 2.3 to 21 ppm.

Cadmium levels in these samples ranged from 2 to 25 ppm. These cadmium concentrations appear to be typical based on a study by Solomon and Hartford (1976) in which household dust was found to contain cadmium levels ranging from 7 to 48 ppm with an average of 18 ppm.

Table 7

DUST SAMPLES FROM RESIDENTIAL SITES

Parameters (ppm)		Type of Dust Sample and Location of Sample Taken by Site Number: Vacuum Cleaner 1	3	4	5	7	10	11	Furnace Filter 6	9
Arsenic	L(Leachable)	6.2	2.4	2.5	2.2	5.4	4.6	2.5	5	1.2
	T(Total)	21	2.7	5.9	2.6	2.9	4.9	2.3	14	4.7
Cadmium	L	5.1	10	4.8	17	20	6.9	3.4	3.3	2.2
	T	9.4	11	4.0	25	21	20	3.6	3.7	2
Lead	L	77	230	60	170	230	56	37	50	140
	T	110	280	62	280	220	61	46	51	170
Calcium	L	11,000	100,000	30,000	75,000	48,000	20,000	23,000	7,000	7,500
	T	25,000	110,000	30,000	83,000	66,000	25,500	32,000	72,000	53,000
Sodium	L	6,800	4,500	4,400	4,600	3,500	10,000	68,000	2,600	2,200
	T	15,200	11,000	7,200	9,200	5,700	12,000	86,000	55,000	78,000
Bromide	L	36	<0.8	50	<4	32	64	<4	8	24
	T	<250	460	<250	<150	<120	<500	<200	1,500	25
Chloride	L	11,300	1,500	3,060	18,500	2,900	29,500	13,200	2,420	1,970
	T	34,000	23,300	146,000	77,500	9,700	87,000	52,000	2,610	1,970
Fluoride	L	22	14	30	9.6	5.6	7.2	16	14	5.6
	T	<25	5	<50	<10	<5	5	<20	<20	6
Iodide	L	1.2	0.1	2	1.0	1.1	1.2	<0.04	0.2	0.24
	T	<2.4	<2.5	<2.5	1.9	<1.2	<5	<2.1	<1.5	4.8
Organic Compounds Bis(2-ethylhexyl)phthalate		160	280	800	24	100	240	49	1,630	42
Butylbenzyl phthalate		50	61	35	4.3	31	12	5.4	91	3
Diethyl phthalate		6.6	1	4		1.8		0.42		
Di-n-butyl phthalate		33	10	19		14		6.6	20	
Di-n-octyl phthalate		26								
Phenol					1.1	.92			610	
Fluoranthene		3.3				1				
Napthalene						28				
Pyrene		4.1				1.7				
Pentachlorophenol		0.6	0.4					0.42		
PBBs		ND	ND	ND	ND	ND	ND			
PCBs		ND					ND			
Arochlor 1232						8.5*				
Arochlor 1260			0.45*	1*	2.4*	6.6*		0.3*	5*	0.35*
Pesticides		ND	ND		ND	ND	ND			
Chlordane				0.3*					4*	
Tentatively Identified Compounds (quantity detected)		13	10	10	9	11	3	10	7	11

ppm - All values are expressed in parts per million.
ND - Not detected in the sample.
< - Actual value, if present, is less than stated value.
* - Was detected by GC/EC but could not be confirmed by GC/MS.
Leachable - Amount extracted from the sample by dilute acid washing.
Total - Total amount in the sample (leachable plus remaining).

Lead concentrations in the Hemlock dust samples ranged from 46 to 280 ppm. These levels are slightly lower than those reported by Solomon and Hartford (1976) who found average levels of 600 ppm with a range of 170 to 1,440 ppm.

Among the organic compounds detected, the phthalate compounds were the most common. Their presence is expected because of the number of household products which would contain such compounds. Perhaps the largest use of these compounds is in manufacturing plastics. Some plastics may contain up to 60% phthalates (EPA Quality Criteria for Water, 1976). Other products containing phthalates which would make them common in the home include:

paints
varnishes
rust preventatives
flame retardant chemicals
chemical deodorizers
adhesives
cleaning agents and compounds
household aerosols
floorwaxes

(Initial Report of the TSCA Interagency Testing Committee, 1978)

Phenol was detected in two of the dust samples. It is an organic compound which can originate from many sources including chemical oxidation processes, human and other organic wastes, microbial degradation of pesticides and other naturally occurring sources (EPA Quality Criteria for Water, 1976). The large level of phenol detected in the furnace dust from site number 6 may have originated from the filter itself. To collect the dust, the fiberglass material contained in the filter had to be removed and included in the sample. Phenol, which is also used in many chemical processes, could have been used in the manufacturing of the filter or have been in a coating which may have been present on the filter.

In two dust samples, three compounds normally associated with by-products of incomplete combustion were detected in small amounts. These compounds are fluoranthene, napthalene and pyrene. Although these compounds are widely distributed in the environment and can be found in the air, water, soil, sediments, and plant

and animal tissues (EPA Ambient Water Quality Criteria, PAH), their presence at these detectable levels suggest that they were formed during combustion processes in these homes. At site number 1, a wood-burning stove was used occasionally. This stove is a likely source for these compounds. Although a specific source was not identified at site number 7, these compounds could have been produced from a variety of sources such as the burning of methane gas (Hoffman, Wynder, 1968), coal, oil and wood. The compounds can also be found in cigarette smoke (EPA Ambient Water Quality Criteria, Fluoranthene).

Pentachlorophenol, a chemical compound commonly used as a pesticide and as a wood preservative, was found in trace amounts in three of the dust samples. Additional sources of pentachlorophenol in the home environment may include such products as:

adhesives	textiles
oils	carpet shampoos
paints	fabrics
rubber	(Conklin, Fox, 1978).

These products are sometimes treated with pentachlorophenol because of its effectiveness as a fungicide and bactericide, and in preventing mildew.

Two types of PCBs (polychlorinated biphenyls), designated as Arochlor 1232 and Arochlor 1260, were identified by electron capture gas chromatography (GC/EC) in 7 of the dust samples at levels ranging from 0.3 to 8.5 ppm. However, these compounds could not be detected by gas chromatography/mass spectrometry when the samples were reanalyzed. These PCBs, if actually present in the samples, are believed to be at background levels for dust. PCBs were once widely used in many products and would still be found in some products within the home. Arochlors 1232 and 1260 were used in adhesives, surface coatings, paints, sealants, and textiles, and as a de-lustering agent for rayons (Interdepartmental Task Force on PCBs, 1972). Other possible sources of PCBs in the home environment

include older fluorescent lights, and appliances and electrical equipment which have components containing PCBs (MacLeod, 1979).

Dr. Thomas Murphy, of DePaul University, recently completed a study in which dust samples collected from homes and buildings in the Lake Michigan area were analyzed for PCBs. Preliminary results (letter of April 25, 1980 from Dr. Murphy) showed PCB levels in the dust samples to range from 1.2 to 58 ppm with a median level of 9 ppm. In an unpublished report, Dr. Murphy states that these levels of PCBs in dust appear to be representative of background levels of PCBs found in the air from various sources.

One pesticide, chlordane, was detected by GC/EC in two of the dust samples. The presence of chlordane in the samples could not be confirmed by GC/MS analysis. Even if present, the levels of chlordane detected in the two samples did not appear to be high. One study (Starr, et. al. 1974) found chlordane in 45 household dust samples at levels ranging from 1.79 to 41.36 ppm with an average of 7.59 ppm.

Twenty-two additional compounds were tentatively identified in the dust samples. These are listed in Table 6, on pages 27 and 28. As was discussed on pages 33 and 34 in the section on the soil samples, these compounds most likely originated from natural organic matter present in these types of samples. Chemical compounds indicating a contamination problem were not detected.

5. Sediment and sludge

Sediment samples were collected from two wells, no longer in use, from sites numbered 6 and 7. Also a sludge sample was collected from the septic tank located at site number 12. The results from these samples are listed in Table 8, on page 39. The levels of inorganics found in these samples do not appear to be significant or to indicate a contamination problem.

Table 8

SEDIMENT AND SLUDGE SAMPLES FROM RESIDENTIAL SITES

PARAMETERS (ppm)		Site Number: Well 6	Sediment 7	Septic Tank Sludge 12
Arsenic	L (Leachable)	10.8	8.2	4.6
	T (Total)	9.2	44	9.8
Cadmium	L	0.33	3.3	1.2
	T	0.28	2.9	3.1
Lead	L	12.7	58	11
	T	18	56	67
Calcium	L	46,000	12,000	5670
	T	59,200	13,800	82,500
Sodium	L	890	960	1180
	T	6900	6460	2100
Bromide	L	<3.3	<110	<10
	T	<80	<110	<250
Chloride	L	42,800	470	27,800
	T	42,800	10,100	35,600
Fluoride	L	<80	40	1,550
	T	<80	89	1,550
Iodide	L	0.89	<1	0.77
	T	<0.8	<1	<250
Organic Compounds		ND		
Bis(2-ethylhexyl) phthalate				2.6
Butyl benzyl phthalate				14.2
Diethyl phthalate				1.6
Di-n-butyl phthalate			0.49	1.9
Acenaphthalene			0.24	
Benzo(a)anthracene			1.6	
Chrysene			2.3	
Fluoranthene			1	
Benzo (b+k) fluoranthene			1.1	
Pyrene			2	
Benzo(a)pyrene			1.3	
Pesticides		ND	ND	ND
PCBs		ND	ND	ND
PBBs		ND	ND	ND
Tentatively Identified Compounds (quantity identified)		3	4	7

Leachable - Amount extracted from the sample by dilute acid washing.
Total - Total amount in the sample (leachable plus remaining).
ppm - All values are expressed in parts per million.
ND - Not detected in the sample.
< - Actual value is less than given value.

of the organic compounds detected in the samples, 4 phthalates were found in the septic tank sludge. The presence of these compounds in sludge is probably due to the fact that phthalates are contained in many household products.

In the well sediment from site number 7, a phthalate and seven other compounds, known as polycyclic aromatic hydrocarbons, were found. The most likely source of these compounds is contamination from surface water runoff. A cracked concrete cap was used to cover the well. This would be inadequate protection because the crack would have permitted water runoff to enter the well.

Additional compounds identified by the GC/MS scan, listed in Table 6, on pages 27 and 28 are chemical compounds which would occur naturally in these samples and are not associated with contamination.

6. Tests for dioxin

Seven environmental samples from the residential sites were analyzed for dioxin. The following are the samples which were analyzed:

1) well sediment (site #6)
2) still residue (site # 6)
3) septic tank sludge (site #12)
4) downspout soil (site #4)
5) downspout soil (site #6)
6) vacuum dust (site #4)
7) furnace filter dust (site #6)

Dioxin was not detected in any of the samples.

C. Samples From Hemlock's Municipal Water And Sewage Treatment Systems

1. Water

The results of the water sample collected from the Hemlock municipal system are listed in Table 9, on page 42.

The levels of the inorganics present in the water sample did not exceed existing EPA standards. The inorganic parameters, for which EPA does not have standards, were not at levels known to be harmful to health. Each of these inorganics in water were discussed previously beginning on page 14.

The organic compound, methylene chloride, was detected at a level of 25 parts per billion. This compound was detected in several of the other water samples collected (See page 21). Quality assurance procedures used indicate that its presence is due to laboratory contamination.

Three organic compounds, which sometimes indicate fecal contamination of the water, were detected by a GC/MS scan. However, fecal contamination was not indicated by fecal coliform tests performed by MDPH.

2. Sludge

A sludge sample was collected from the sewage treatment facility in Hemlock. The results from this sample are listed in Table 9, on page 42.

The results of the analysis of the sludge sample does not indicate evidence of a contamination problem. Levels of arsenic and lead appear to be low according to Lisk's data on sewage sludge (1972), which found the average concentration of arsenic to be 90 ppm and lead to be 1,690 ppm. The cadmium level also appears to be low since cadmium levels in sewage have been found to average 16 ppm, and range from 3 to 3,000 ppm (CAST, 1976). The levels detected for the remaining inorganics are believed to be typical.

Table 9

WATER AND SLUDGE SAMPLES FROM
HEMLOCK'S MUNICIPAL SYSTEMS

WATER

Inorganics		
Arsenic	7	ppb
Cadmium	0.6	ppb
Lead	2	ppb
Calcium	104	ppm
Sodium	75	ppm
Bromide	< 0.01	ppm
Chloride	48	ppm
Fluoride	0.5	ppm
Iodide	< 0.0003	ppm

Organics	
methylene chloride	25 ppb*
Pesticides	ND
PCBs	ND
PBBs	ND

Tentatively Identified Compounds

cholestanol

9-octadecen-1-ol

hexadecanoic acid, 2-oxo, methyl ester

SLUDGE

(All values are in parts per million)

Inorganics	Leachable	Total
Arsenic	7.4	11
Cadmium	1.3	0.83
Lead	16	27
Calcium	43,000	45,800
Sodium	890	7,700
Bromide	< 2.9	< 2.9
Chloride	192	42,400
Fluoride	< 14	< 14
Iodide	< 0.3	< 0.3

Organics	
bis(2-ethylhexyl) phthalate	4.9
di-n-butyl phthalate	0.86
Pesticides	ND
PCBs	ND
PBBs	ND

Tentatively Identified Compounds

eicosanol
heptadecanol
undecane
2-butanone
tetradecanoic acid
hexadecanoic acid
heneicosanoic acid
benzeneacetic acid

ppm - parts per million
ppb - parts per billion
ND - Not detected in the sample
* - Value may be attributed to laboratory contamination.
< - Actual value, if present, is less than stated value.
Leachable - Amount extracted from the sample by dilute acid washing.
Total - Total amount in the sample (leachable plus remaining).

The detected organic compounds included two phthalates. Because of their widespread use in many products, their presence is expected. The remaining compounds which were identified by the GC/MS scan are thought to originate from biological sources and are not known to indicate a contamination problem.

D. Biological Samples

Plant, fish and other animal tissue samples were collected from the Hemlock area and analyzed. The results from these samples are listed in Table 10, on pages 45 and 46. Also in this table are numbers or letters which designate the location from which the samples were collected. These numbers or letters are plotted on the map located on page 15.

1. Fish

Fish samples were collected from Marsh Creek, Williams Creek, and McClellan Run in the Hemlock area. Additional fish samples were taken from two locations on the Tittabawassee River near Midland, Michigan. The fish collected from the Tittabawassee were caged fish which were being monitored by the MDNR. One location on the Tittabawassee was upstream from the Dow Company plant site and the other was downstream from Dow. The caged fish from the Tittabawasee were included in this study to determine if chemical contamination was still present in fish downstream of Dow Chemical. The MDPH previously had issued a warning against consuming fish from this river because of chemical contamination.

The levels of arsenic, cadmium and lead found in the fish were not excessive. Lisk (1972) reports average levels of these metals in fresh water fish to be 0.03-0.5 ppm, 0.02-0.15 ppm, and 0.5-2 ppm, respectively.

Phenol, an organic compound, was found in 4 of the samples. The presence of phenol in fish tissues could be due to a number of reasons since it is a compound widely found in the environment from both natural and anthropogenic sources. One source of phenol is the microbial breakdown of certain pesticides. However, this appears to be an unlikely source, in this case, because no pesticides were found in the fish. If pesticide degradation was the source of phenol, the pesticides would have accumulated and been found in the fish tissues. Other possible sources of phenol in fish are natural sources. The natural sources

Table 10
PLANT AND ANIMAL TISSUE SAMPLES

	Algae	Fish #1	Fish #2	Fish #3	Fish #4	Fish #5	Fish #6	Goose Fat
Location	NA	A	B	C	C	*	**	4
Parameters								
Arsenic	NA	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.5
Cadmium	NA	0.06	0.023	0.026	0.037	0.036	0.038	0.011
Lead	NA	<0.02	<0.02	<0.02	0.11	0.12	0.1	<0.05
Organic Compounds (ppm)						ND		ND
phenol	0.17	0.18	0.02	0.9				
di-n-butyl phthalate					2		1.4	
diethyl phthalate		0.07						
Pesticides (ppm)	ND	ND	ND	ND	ND	ND	ND	ND
PCBs (ppm)	ND	ND	ND	ND	ND	ND	ND	ND
PBBs (ppm)	ND	ND	ND	ND	ND	ND	ND	ND
Dioxin (ppt)	NA	ND	ND	ND	ND	ND	23	ND
Tentatively Identified Compounds								
(Alcohols)								
heptadecanol								
4-methyl phenol	X							
glycerol								
cholest-5-en-3-ol			X	X		X	X	
(Aldehydes)								
tetradecanal		X		X				
octadecanal								
octadecenal								X
2,4,nonadienal								X
(Carboxylic Acids)								
butanoic acid						X		
3-methyl butanoic acid	X							
octanoic acid, methyl ester								X
8-methyl decanoic acid, methyl ester	X							
undecanoic acid, methyl ester			X					
cyclopentane undecanoic acid, methyl ester				X				
tetradecanoic acid	X					X		
tetradecanoic acid, methyl ester				X		X		X
pentadecanoic acid, metnyl ester								
14-methylpentadecanoic acid, methyl ester	X	X	X	X		X		
hexadecanoic acid			X				X	
hexadecanoic acid, methyl ester				X	X	X		X
14-methylhexadecanoic acid, methyl ester								
15-methylhexadecanoic acid, methyl ester				X				
heptadecanoic acid, methyl ester								
16-metnylheptadecanoic acid, methyl ester		X						
octadecenoic acid								
octadecenoic acid, methyl ester						X		
9-octadecenoic acid								
10-octadecenoic acid, metnyl ester					X			
14-octadecenoic acid, metnyl ester				X				
17-octadecenoic acid, methyl ester		X	X					
10,13-octadecadienoic acid, methyl ester								
eicosanoic acid, metnyl ester								
heneicosanoic acid, methyl ester				X				
Other Compounds								
1,1-dodecanediol diacetate						X		
nonadecane							X	
1,1-dimethoxyhexane								
benzoic acid								

ppm - parts per million.
ppt - parts per trillion.
NA - Not analyzed for in the sample.
ND - Not detected in the sample.
< - Actual value, if present, is less than stated value.
* - Caged fish from upstream Tittabawassee.
** - Caged fish from downstream Tittabawassee.
X - Indicates the compound was tentatively identified in the sample.

Table 10

(continued)

	Goose Liver	Chicken Fat	Chicken Fat	Chicken Liver	Chicken Liver	Cow Fat	Cow Liver	Cow Kidney	Deer Fat	Deer Liver	Squirrel Muscle	Squirrel Organs
Location	4	5	5	5	5	6	6	6	R	R	S	S
Parameters												
Arsenic	<0.15	<0.5	<0.5	<0.15	<0.15	<0.15	<0.15	<0.15	<0.5	<0.15	<0.15	<0.15
Cadmium	0.36	<0.004	0.006	0.34	0.62	0.037	2.2	0.70	<.004	0.11	0.008	0.22
Lead	0.10	0.29	0.25	0.15	0.12	0.11	0.23	0.13	<.05	0.13	0.14	1.1
Organic Compounds (ppm)	ND	ND	ND	ND	ND			ND				
phenol						0.13	.75		0.06	.02		.86
di-n-butyl phthalate												
diethyl phthalate									0.02			
Pesticides (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND
PCBs (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND
PBBs (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND
Dioxin (ppt)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND
Tentatively Identified Compounds												
(Alcohols)												
heptadecanol												X
4-methyl phenol												
glycerol												X
cholest-5-en-3-ol	X	X	X	X	X			X	X			
(Aldehydes)												
tetradecanal	X								X			X
octadecanal	X											
octadecenal												
2,4,nonadienal												
(Carboxylic Acids)												
butanoic acid												
3-methyl butanoic acid												
octanoic acid, methyl ester												
8-methyl decanoic acid, methyl ester												
undecanoic acid, methyl ester							X					
cyclopentane undecanoic acid, methyl ester												
tetradecanoic acid							X					
tetradecanoic acid, methyl ester		X	X	X	X	X		X	X			X
pentadecanoic acid, methyl ester					X							
14-methylpentadecanoic acid, methyl ester	X	X	X					X	X	X		X
hexadecanoic acid	X			X	X		X			X		X
hexadecanoic acid, methyl ester		X		X	X	X	X		X			X
14-methylhexadecanoic acid, methyl ester							X					
15-methylhexadecanoic acid, methyl ester												
heptadecanoic acid, methyl ester					X							
16-methylheptadecanoic acid, methyl ester	X	X	X	X	X	X	X		X	X		
octadecenoic acid		X										
octadecenoic acid, methyl ester												
9-octadecenoic acid						X						
10-octadecenoic acid, methyl ester								X				
14-octadecenoic acid, methyl ester												X
17-octadecenoic acid, methyl ester		X										
10,13-octadecadienoic acid, methyl ester												X
eicosanoic acid, methyl ester												X
heneicosanoic acid, methyl ester				X			X	X				X
Other Compounds												
1,1-dodecanediol diacetate												
nonadecane							X					
1,1-dimethoxyhexane							X					
benzoic acid												

ppm - parts per million.
ppt - parts per trillion.
NA - Not analyzed for in the sample.
ND - Not detected in the sample.
< - Actual value, if present, is less than stated value.
* - Caged fish from upstream Tittabawassee.
** - Caged fish from downstream Tittabawassee.
X - Indicates the compound was tentatively identified in the sample.

include certain aquatic plants which produce phenol and the decomposition of vegetation such as oak leaves, which enter the water (Hoak, 1957). Another potential source may be industrial discharges.

Two phthalates were also present in three fish samples. As mentioned previously, phthalates are used in many products and have been found throughout the environment and are commonly present in waterways and aquatic life (EPA Initial Report of the TSCA Interagency Testing Committee, 1978). The levels of phthalates found in these fish samples are not believed to be unusual. One type of phthalate was reported to be present in fish, collected from various locations across the country, at levels ranging from 0.2 to 10 ppm (Stalling et. al., 1973).

Dioxin was detected in a fish sample from site number 6, at a level of 23 parts per trillion. This sample was from the caged fish located downstream from Dow on the Tittabawassee. In 1978, 26 out of 35 fish samples, collected from the Tittabawassee, Saginaw, and Grand Rivers, contained dioxin (EPA Memo on Dioxin, December 20, 1978). Levels detected in the fish from the 1978 study ranged from 4 to 695 parts per trillion. Dioxin was not detected in the other fish samples.

A number of additional organic compounds were identified in the fish samples by the GC/MS scan. These compounds, are believed to be part of the normally occurring background compounds which one would expect to be present in these samples. They are not known to indicate chemical contamination of the fish.

2. Animal Tissues

Tissue samples were analyzed from a goose, two chickens, three cows, a deer and a squirrel, taken from the Hemlock area. Arsenic was not detected in any of the samples. Based on personal communication (July 2, 1980) with Val Beasley, D.V.M., of the University of Illinois, College of Veterinary Medicine,

the levels of cadmium and lead found were at background levels and do not indicate a contamination problem. Dr. Beasley commented that the highest cadmium level detected in cow liver (2.2 ppm) was slightly above levels normally found. However, he believed that it was not high enough to cause health problems in cattle.

The organic compound, phenol, was detected in 5 of the tissue samples. The phenol levels detected are not uncommon according to Dr. Fred Oehme (personal communication on July 2, 1980), who is a veterinarian-toxicologist at Kansas State University. Dr. Oehme stated that phenolic compounds are naturally found in animal and plant tissues. Also, levels of phenol can increase in animal tissues if the animal feeds on lush vegetation.

Diethyl phthalate was also found, in trace amounts, in the deer fat sample. Because of the widespread distribution of phthalates in the environment, it does not seem unusual that this compound would be found in some animal tissues.

Other chemical compounds which were detected in the samples appear to be background compounds which naturally occur in tissues. Pesticides, PCBs, PBBs, and dioxin were not detected in these samples.

In addition to those samples listed in Table 10 on pages 45 and 46, two more cow fat samples from site number 6 were analyzed for dioxin. Dioxin was not found in either of these samples.

3. Plant

Algae, growing at the base of a water well at residence number 6, were analyzed for organic chemical compounds. The results of the analysis are contained in Table 10, on pages 45 and 46.

Evidence of chemical contamination was not found in the plant sample. The phenolic and carboxylic acid compounds detected are believed to be naturally present in plant tissues.

E. Evaluation of Goose Wing Deformity

A goose from site number four was born with a deformity of one wing which made it appear to be attached backwards to the body. The goose was autopsied and tissue samples were analyzed (Table 10, pages 45 and 46) to determine if a chemical contaminant may have caused this deformity. The goose was examined by a Michigan State University veterinarian, and according to the autopsy report (November 28, 1979), the deformity was actually an increased flexibility of the joints close to the base of the wing. This allowed the wing to rotate to the extent that the feathers appeared to point in the wrong direction when the wing was flexed. Based on personal communications (July 2, 1980) with Dr. Val Beasley (a veterinarian from the University of Illinois, College of Veterinary Medicine), this type of deformity may have been caused by a mal-position of the unhatched bird during the development process, a genetic disorder, or a chemical contaminant. However, chemical contaminants were not observed in the tissues analyzed. According to Dr. Roland Winterfield (personal communication, July 2, 1980), a specialist in avian diseases at Purdue University, the wing disorder is most likely due to a genetic defect. Dr. Winterfield stated that it was most likely not related to a chemical contaminant since other deformities or problems were not found in the goose.

F. Fish Bioconcentration Studies

Two fish bioconcentration studies were conducted in the Hemlock area. These studies involved placing fathead minnows in tanks, filled with water from the test sites, for a 30-day period. Two fish samples were collected before the studies began (day 0) to serve as controls, and on day 15 and day 30. These samples were analyzed to determine if trace chemical contaminants were present, which would accumulate in the fish from the water.

The first bioconcentration study was performed during October, 1979, using the well water from site number 4. The second fish bioconcentration study was conducted during April, 1980, using water from the Hemlock municipal supply. The results of the fish sample analyses are listed in Table 11(a), on page 51, and in Table 11(b), on page 52. Based on the chemical compounds identified and the levels detected in the control and the duplicate fish samples, there appear to be no significant differences in the levels or types of chemicals identified. The bioconcentration studies did not indicate contamination of the water.

Table 11(a)

FISH TISSUE SAMPLES FROM 30 DAY
BIOCONCENTRATION STUDY USING
WATER FROM RESIDENTIAL SITE #4

rameters	Control Day 0	Control Day 0	Day 15	Day 15	Day 30	Day 30
rganics (ppm)						
senic	0.32	<0.15	0.37	1.0	0.53	0.83
dmium	0.068	0.044	0.032	0.080	0.13	0.077
ad	0.81	0.18	0.13	0.13	0.12	0.15
ganic Compounds (ppm)				ND	ND	
enol	1.0					0.17
ethyl phthalate			0.23			0.3
-n-butyl phthalate		0.6				2.7
sticides (ppm)	ND	ND	ND	ND	ND	ND
Bs (ppm)	ND	ND	ND	ND	ND	ND
Bs (ppm)	ND	ND	ND	ND	ND	ND
oxin (ppt)	ND	ND	ND	ND	ND	ND
ntatively Identified Compounds						
ycerol						X
olest-5-en-3-ol	X	X			X	
tradecanal				X		
tadecanal				X		
canoic acid, methyl ester						X
tradecanoic acid		X		X		
tradecanoic acid, methyl ester		X	X		X	X
-methyl tetradecanoic acid, methyl ester						X
-methyl pentadecanoic acid, methyl ester	X		X		X	X
xadecanoic acid						X
xadecanoic acid, methyl ester		X		X		X
-methyl hexadecanoic acid, methyl ester			X			
-methyl hexadecanoic acid, methyl ester		X				
xadecenoic acid, methyl ester		X				
-methyl heptadecanoic acid, methyl ester	X					
-methyl heptadecanoic acid, methyl ester					X	
-octadecenoic acid, methyl ester				X		
-eicosenoic acid, methyl ester			X			
neicosanoic acid, methyl ester			X			X
idecane						X

pm - parts per million.
pt - parts per trillion.
- Not detected in the sample.
< - Actual value, if present, is less than stated value.
X - Indicates the compound was tentatively identified in the sample.

Table 11(b)

FISH TISSUE SAMPLES FROM 30 DAY
BIOCONCENTRATION STUDY USING WATER FROM
HEMLOCK MUNICIPAL WATER SYSTEM.

Parameters	Control Day 0	Control Day 0	Day 15	Day 30	Blank
Inorganics (ppm)					
Arsenic	0.16	0.21	0.20	0.33	0.66
Cadmium	0.33	0.45	1.1	0.33	0.01
Lead	0.88	1.3	0.94	<0.4	0.14
Thallium	<0.6	<0.6	<0.7	<0.4	<0.07
Organic Compounds (ppm)	ND	ND		ND	ND
phenol			ND		
diethyl phthalate			0.4		
di-n-butyl phthalate			0.7		
Pesticides (ppm)	ND	ND	ND	ND	ND
PCBs (ppm)	ND	ND	ND	ND	ND
PBBs (ppm)	ND	ND	ND	ND	ND
Dioxin (ppt)	ND	ND	ND	ND	ND
Tentatively Identified Compounds					
tetradecanoic acid	X	X	X	X	
hexadecanoic acid	X	X	X	X	
9-hexadecanoic acid	X	X	X	X	
octadecanoic acid	X	X	X	X	

ppm - parts per million.
ppt - parts per trillion.
ND - Not detected in the sample.
< - Actual value, if present, is less than stated value.
X - Indicates the compound was tentatively identified in the sample.

G. Samples From Dow's Brine System And Areas Located Near It

Samples were collected from the brine system and areas located near it which may have been affected by past spills or leaks in the system. The locations and descriptions of the samples collected are indicated in Table 12, page 54, and the sample results are listed in Table 13, pages 55 and 56.

Four brine samples were collected from different locations along the system. The levels of the inorganic parameters detected, appear to be characteristic of the brine and are not considered significant. Two organic compounds, which probably resulted from background or laboratory contamination, were detected in the brine samples. Methylene chloride, detected in one of the brine samples, was also found in control samples. This indicates that sample contamination had occurred. The other organic compound, tentatively identified by the GC/MS scan, was diethylene glycol. This is a chemical compound which is used as a solvent, plasticizer, and surfactant, and can be found in plastics, synthetic sponges, paper products, cork compositions, adhesives, and dyes (Hawley, 1977). The sample in which diethylene glycol was identified was originally collected by a local resident and was stored in a glass jar. Trace contamination of the sample could have occurred from the jar or lid before the sample was transferred to an approved sample container. Diethylene glycol was not detected in the soil sample from the area where the spilled brine had been collected.

Soil and sediment samples were collected from areas near the brine system and analyzed for specific inorganic chemicals. Significant levels of these inorganics were not found. The organic compounds identified in these samples, with the exception of di-n-butyl phthalate, are believed to have originated from natural background sources. Di-n-butyl phthalate and similar compounds, are commonly found in the environment and could have originated from many sources.

Table 12
DESCRIPTION OF SAMPLES COLLECTED FROM THE DOW BRINE SYSTEM AND AREAS LOCATED NEAR IT.

Type of Sample	Location *	Description
brine	F	Waste brine collected from a valve near the injection well.
brine[1]	F	Waste brine which had leaked from the pipe and had collected at the base of the well.
brine	G	Brine which had been collected earlier by one of the local residents from a spill site.
brine	**	Brine released from the filtering system of the #6 lagoon located on the Dow plant site in Midland. (Location not marked on the map.)
soil	F	Surface soil near the injection well.
soil	G	Surface soil from a spill site located along the brine system.
sediment	H	Sediment from a sandy area next to the brine system.
sediment	E	Creek bed sediment taken from th area known as Smith Drain.
sediment	D	Sediment from the injection well pond.
sediment	I	Sediment collected from an injection well head which was being dismantled.
sediment	J	Sediment which was inside a brin injection pipe at the horizontal orifice plate near the well head
sediment	K	Pipe scrapings from under a gas separator located on a brine production well. This well is located in Midland County, one mile south of Midland. The exact location of the well is not mark on the map.

* - Locations indicated on map (page 15).
** - Location not marked on the map.
1 - Addition sample collected at Location F

Table 13
SAMPLES COLLECTED FROM DOW'S BRINE SYSTEM
AND AREAS LOCATED NEAR IT.

Parameters (ppm)		Brine	Brine	Brine	Brine	Soil	Soil	Sandpit Sediment	Creek Sediment	Brine Pond Sediment	Pipe Sediment	Pipe Sediment	Pipe Sediment
Location		F	F	G	*	F	G	H	E	D	I	J	K
Arsenic	L(Leachable)					0.19	0.23	0.43	2.2	12	0.41	<0.2	2.2
	T(Total)	.008	<.005	<.005	.012	8.8	0.62	19	18	134	28	8.7	71
Cadmium	L					0.10	0.07	.08	.08	0.4	0.18	0.2	3.6
	T	1.1	0.04	<.005	.02	0.51	0.32	0.38	.08	0.3	4.4	2.8	3.6
Lead	L					16	2	2.3	1.5	9.4	7.2	8.3	49
	T	.006	10.6	1.5	.003	23	4.4	38	15	19	12	200	110
Calcium	L					33,000	10,000	19,900	2,400	44,700	96,000	187,000	104,000
	T	17,200	210,000	170,000	18,500	46,000	11,500	155,900	9,600	69,500	96,000	191,000	105,000
Sodium	L					1,500	160	160	86	1,440	15,000	13,000	4,900
	T	27,500	32,500	17,500	32,500	6,500	2,100	270	8,000	7,440	16,800	14,200	4,900
Bromide	L					6.4	3	<5.4	21	92	NA	NA	NA
	T	29	25	<0.5	12	<10	390	<130	<80	<120			
Chloride	L					6,270	990	4,600	1,920	4,300	NA	NA	NA
	T	211,000	208,000	126,000	210,000	6,280	10,300	16,700	7,840	19,600			
Fluoride	L					5.8	8	97	3	<120	NA	NA	NA
	T	10	10	10	16	25	<10	<130	80	125			
Iodide	L					0.06	< 0.01	0.35	0.2	1.8	NA	NA	NA
	T	7.7	8.7	5.1	8.3	1	<1.2	<1.3	<0.8	<1.2			
Purgeable Organics		ND		NA	ND	NA	NA	NA	NA	NA	NA	NA	NA
methylene chloride			0.2**										
Nonpurgeable Organics		ND	ND	ND	ND	ND		ND	ND	ND		ND	
bis(2-ethylhexyl)phthalate											0.8		
di-n-butyl phthalate							3.8				4.6		
4-chloro-m-cresol											0.18		
2-chlorophenol													2.2
Pesticides		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PBBs		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dioxin		NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND

Table 13
(continued)

Tentatively Identified Compounds	Brine	Brine[1]	Brine	Brine	Soil	Soil	Sandpit Sediment	Creek Sediment	Brine Pond Sediment	Pipe Sediment	Pipe Sediment	Pipe Sediment
	ND	ND										
hexadecanol				X	X							
heptadecanol							X	X	X	X		
nonadecanol						X		X				
eicosanol					X				X			
octanoic acid								X				
undecenoic acid, methyl ester							X		X			
cyclopentane undecanoic acid, methyl ester							X	X				
tetradecanoic acid									X			
pentadecanoic acid						X						
hexadecanoic acid					X	X	X	X	X			
octadecanoic acid									X			
heneicosanoic acid, methyl ester							X	X	X			
octadecanal									X			
nonane												X
2-methyl nonane						X						
undecane							X				X	X
2,6,11-trimethyldodecane											X	
hexadecane											X	
hexadecene						X						
tetramethylheptadecane											X	X
octadecane										X	X	
1,1-dodecanediol diacetate						X						
diethylene glycol			X									
2,6-bis(1,1-dimethylethyl) 4-methyl phenol										X		

ppm - All values are expressed in parts per million.
NA - Not analyzed for in the sample.
ND - Not detected in the sample.
< - Actual value, if present, is less than stated value.
Leachable - Amount extracted from the sample by dilute acid washing.
Total - Total amount in the sample (leachable plus remaining).
* - Waste brine from the Dow plant in Midland.
** - Value may be attributed to possible laboratory or background contamination.
X - Indicates the compound was tentatively identified in the sample.

EPA requested permission from Dow to collect sediment samples from the waste brine lagoon located at the Midland plant site. Dow refused EPA's request based on their rationale that the sediment samples would not be representative of the chemical composition of the brine. Dow indicated that the waste brine was sand-filtered, thereby removing chemical contaminants, before being released from the lagoon to brine transmission lines. However, Dow did permit sampling of pipe sediment within the brine well injection system. As a result, three pipe sediment samples, two from brine injection wells and one from a brine production well, were collected.

Four synthetic organic chemical compounds were detected in sediments within two of the pipes. These pipes are located at the brine production and injection wells near Midland. Non-natural chemical compounds were not detected in the injection well near Hemlock. The four organic chemicals detected were:

1) bis(2-ethylhexyl) phthalate
2) di-n-butyl phthalate
3) 4-chloro-m-cresol
4) 2-chlorophenol

In addition, a duplicate sample from location J was analyzed at a second laboratory. From these analyses, two additional synthetic chemical compounds, hexachlorobenzene (2.5 ppb) and pentachloroanisole (40 ppb), were detected. However, when analyzed by GC/MS, the presence of these compounds could not be confirmed.

The three pipe sediment samples were also analyzed for dioxin. Using current state-of-the-art methodology, dioxin was not found in these samples.

H. Evaluation of Dow's Brine Well Design and Construction

EPA staff reviewed technical data on the brine production and injection wells operated by the Dow Chemical Company of Midland, Michigan. These data were reviewed to determine what impact Dow's brine wells might have on shallower aquifers used for water supplies in the Hemlock area. Part of this information was originally requested through the Freedom of Information Act and was submitted by Dow to the Congressional Subcommittee on Oversight of Government Management on June 25, 1979. This information was later forwarded to EPA on October 30, 1979 (Appendix 1, page 63). EPA staff reviewed these data and were unable to make a valid engineering evaluation of the mechanical conditions of the wells because insufficient information was provided.

During a meeting with Dow representatives on January 24, 1980, additional information was requested by EPA staff (Appendix 2, page 67). In response to the request, Dow provided the necessary information to EPA (Appendix 3, page 69). The information included details on injection well number 42 (location "J" on the map) which is located near Hemlock.

Based on the avaliable data, EPA staff concluded that the program followed by Dow in the construction of their brine wells exceed current U.S. Geological Survey, Division of Oil and Gas, On Land Injection Standards. In addition, no evidence was found to suspect that these wells would be responsible for cross-contamination between the geological formations.

A limitation to EPA's evaluation was that insufficient data were available on wells constructed before 1970. Consequently, EPA was unable to make an evaluation of these wells. It is Dow's position that, before 1970, the best technology available at that time was used to construct the wells.

V. CONCLUSION

Chemical contamination was not detected by analysis of the environmental and tissue samples collected in the Hemlock, Michigan area. Based on available information, the levels of the inorganic and organic chemicals in these samples appeared to be within normal bounds. Most of the organic chemical compounds identified are naturally occurring in the environment. Several synthetic chemical compounds were also present. However, these compounds are frequently found in the home and ambient environment due to the presence of consumer products which contain them. The quality of water from certain wells in the area contained elevated levels of sodium chloride salt which can affect the taste of the water.

In summary, based on results from a large number and wide variety of samples, the United States Environmental Protection Agency has found no evidence of chemical contamination of the environment in the Hemlock, Michigan area.

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United States Senate

COMMITTEE ON
GOVERNMENTAL AFFAIRS
SUBCOMMITTEE ON
OVERSIGHT OF GOVERNMENT MANAGEMENT
WASHINGTON, D.C. 20510

October 30, 1979

Mr. Karl Bremer
Region V
Environmental Protection Agency
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Bremer:

Per our discussion of October 17, I have enclosed a copy of the Subcommittee's correspondence requesting technical data from Dow Chemical Company relative to the company's brine production and injection wells. When comparing the requests to information received by the Subcommittee, you will note that the response is in fact only a partial one. The burden of a full response would have been too large an imposition on the company at that time.

I would also like to take this opportunity to thank you for your appearance at and involvement in the Hemlock town meeting. I found your input to be quite helpful in clearing up residents' impressions of EPA activities relative to that area.

Please don't hesitate to contact me if I can be of any further service to you or EPA Region V.

Sincerely,

Richard L. Tallman
Staff Investigator

RLT/fdv
Enclosure

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United States Senate

COMMITTEE ON
GOVERNMENTAL AFFAIRS
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OVERSIGHT OF GOVERNMENT MANAGEMENT
WASHINGTON, D.C. 20510

June 25, 1979

SPECIAL DELIVERY
RETURN RECEIPT REQUESTED

Mr. Paul F. Oreffice
President and Chief Executive Officer
Dow Chemical Company
2030 Dow Center
Midland, Michigan 48640

Dear Mr. Oreffice:

The Subcommittee on Oversight of Government Management is conducting an investigation into governmental implementation of hazardous waste management programs by the Environmental Protection Agency (EPA), the EPA regions and state agencies. Pursuant to this investigation, we are interested in how governmental units have responded to possible problems caused by the brine injection deep wells you are operating or have operated in the Midland, Michigan area. The Subcommittee has been informed that some of these wells were constructed to extract sodium chloride from the earth for your chemical manufacturing processes in Midland, and that the brine sludge residue was pumped back into reinjection wells.

It is also our understanding that the Michigan Department of Natural Resources (DNR) has performed chemical analyses of surface pools in the Fremont-Richland area formed as a result of leaks and/or cracks in your company's brine reinjection lines. The studies performed by DNR indicate that substances other than brine residues were present in these surface pools, such as flourides, ammonia, certain phenolic compounds and other materials.

The Subcommittee is interested in the government's response to possible chemical contamination of the groundwater by such substances in Midland, Bay, Saginaw and Gratiot counties. In order to assist the Subcommittee in its investigation, we would appreciate your providing the following materials by July 9, 1979:

1. Copies of all groundwater and geological studies performed by or for Dow, or under the direction of Dow, covering any part of the area within a 25-mile radius of your Midland facilities. Please also supply any other documents which may indicate geological groundwater flow patterns or geologic subsurface conditions relative to the areas of deep well injection systems.

2. Copies of all chemical laboratory analyses, performed since 1950, of spent brines and brine spills, as well as other liquids, from Dow pipelines in the four counties mentioned above, which Dow may have injected or is injecting into the ground.

3. A copy of all well logs for deep well injection systems, showing the volume of materials injected into those wells to date, as well as injection pressures. Please include with these logs a list and map of all waste injection wells, as well as landfills and surface impoundments owned or once owned by Dow, whether or not these wells, landfills or impoundments are presently in use. How long does Dow maintain such well log information in its files? What record keeping is required of Dow by federal law with respect to these wells, landfills and impoundments?

4. Copies of all inorganic analyses and summary data performed by or for Dow, or under the direction of Dow, which indicate the presence of any heavy and/or pseudo metals in Dow's injected waste streams.

5. Copies of all analyses of organic constituents in the injected wastes, specifically identifying their levels of concentration.

In addition, please respond to the following specific questions:

1. How much waste from the manufacture of trichlorophenol and/or 2,4,5-T has been pumped into Dow's reinjection wells and/or placed in Dow landfills or impoundments? Which wells, landfills and impoundments?

2. At what rates and pressures does Dow dispose of waste material through deep well reinjection systems? Is this rate continuous or intermittant, and are there seasonal fluctuations in these rates? Are these rates low enough to insure the stability of the geologic formations?

3. What types of high molecular weight and/or halogenated organics are present in the waste stream of materials being pumped to your reinjection wells? Please specifically identify types and concentrations of these materials.

4. Have EPA Priority Pollutant Analyses been performed on Dow's waste streams? If so, please provide a copy to the Subcommittee.

5. Has Dow performed any groundwater or well water analyses of wells and water supplies within a 25-mile radius of your Midland facilities within the last two years? If so, please supply these to the Subcommittee.

6. Does Dow have any information which would indicate that groundwater contamination may be caused by abandoned or existing landfills and surface impoundments? If so, please supply such information to the Subcommittee.

7. Has Dow ever encountered any problems in operating injection systems, for example, failure of the injection string within the groundwater aquifer? If so, please describe fully.

8. Does Dow have any information which would indicate that abandoned oil, gas or brine wells or other sources may have contributed or are contributing to groundwater contamination? If so, please supply this information to the Subcommittee.

Thanks for your cooperation in this matter. We realize that this request is detailed. However, the Subcommittee has scheduled hearings on governmental implementation of hazardous waste management programs for later in July and we would appreciate a prompt response. If there are any questions concerning these requests, please contact Richard Tallman of the Subcommittee staff at (202) 224-3682.

Sincerely,

Carl Levin

CL/rt

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

JAN 31 1980

Mr. D. Dick DeLine
Manufacturing Manager
Dow Chemical U.S.A., Michigan Division
47 Building
Midland, Michigan 48640

Dear Mr. DeLine:

Thank you for your cooperation on January 24, 1980 regarding our meeting and the samples obtained from the brine production and injection system. The day proved to be quite productive and will assist in our evaluation of the Hemlock, Michigan area.

As you recall, Mr. Russell Diefenbach requested information during the meeting on typical well records for the brine well injection system. Per your request, Mr. Diefenbach has determined that the following information is needed to continue his evaluation of the Dow injection system (records from the Hemlock, Michigan area are more appropriate):

1. Caliper Surveys for typical injection well(s) that are typical for area.

2. Comparison of calculated cement volumes (w/o Caliper) v.s. cement volume from bond logs.

3. Average % wash out used for cement calculations. How established.

4. Results of Cement Bond Log's cement top v.s. calculated cement tops. (Temp. survey's for CBL if used in lieu of).

5. Is the long casing string kept in tension during cement setting time? After cement sets, is all casing weight set on braden-head or is it slacked-off?

6. What casing accessories are used on long string of casing? Is there pressure test after WOC?

7. Is casing dressed with centralizers to center allow 360° cement sheath?

8. Describe typical cement program for long string.

Your response may be forwarded to my office at your first convenience. I anticipate completion of this part of the evaluation during February, 1980.

Thank you for your consideration.

Sincerely,

Karl E. Bremer

Karl E. Bremer
Toxic Substances Coordinator

cc: Senator Carl Levin

DOW CHEMICAL U.S.A.

February 29, 1980

MICHIGAN DIVISION
MIDLAND, MICHIGAN 48640

Karl E. Bremer
Toxic Substances Coordinator
US EPA Region V
230 South Dearborn Street
Chicago, Illinois 60604

Dear Karl:

Enclosed is the information requested by Mr. Russell Diefenbach through your letter of January 31, 1980. I was pleased that your visit to the Michigan Division was quite productive and will assist you in your evaluation of the Hemlock area.

This information was supplied by Mr. David Cella, Manager of the Brine Chemicals Section and our technical expert in the brine well area. Mr. Cella has been with the Michigan Division since 1970 and his responses to Mr. Diefenbach's inquiries relate to the procedures and technology used over the past ten years. Prior to 1970, the best technology available at the time was used.

1. Caliper surveys for typical injection well(s) that are typical for the area.

   Caliper survey and associated bond logs of three wells in the Hemlock area are enclosed.

   Production Wells #76 and #82
   Injection Well #42

2. Comparison of calculated cement volumes (w/o Caliper) versus cement volume from bond logs.

   The number of sacks of cement and type of cement used in each well are shown on the enclosed "Cementing Service Reports."

   Production Wells #76 and #82
   Injection Well #42

3. Average % wash out used for cement calculations. How established.

Since 1973, we have calipered the open hole. Prior to that time, the normal practice was to use the volumetric difference between bit size and casing size plus 20-30% excess cement.

4. Results of Cement Bond Log's cement top versus calculated cement tops. (Temp. survey's for CBL if used in lieu of).

A comparison of the data recorded on the Cementing Service Report and the 3-Dimensional Velocity Log will give the actual results versus calculated. Please see enclosed reports for production wells #76 and #82 and injection well #42.

5. Is the long casing string kept in tension during cement setting time? After cement sets, is all casing weight set on bradenhead or is it slacked-off?

The long string of casing is held in tension at the surface during cementing operations. After the cement has set, we pull one-half the weight of the free pipe and set the slips.

6. What casing accessories are used on long string of casing? Is there pressure test after WOC?

The following accessories are used on long strings of casing:

(a) regular pattern guide shoe,
(b) cement float collar,
(c) centralizers (3-5/well).

Surface casing and long string are tested at a minimum of 500 psig.

7. Is casing dressed with centralizers to center allow 360° cement sheath?

Centralizers are used on the long string and are normally placed one joint above casing shoe, below and above the Dundee zone, with one or two between the Dundee and casing shoe. A caliper log or the geologists log is used for judgment when placing the centralizers.

8. Describe typical cement program for long string.

A typical long string casing cement program is the same for both production and injection wells, except for casing size. We consider a cement fillup from 200' minimum to 500' above the Dundee zone an adequate cement job. Normally, the target cement top is about 2000' to 2500' from the surface, which is approximately 500-1000' above the Dundee formation. The supervisor on the job is given the latitude to modify the cement program to fit the downhole conditions. The brine field is in the Sylvania formation which is about 1000' to 1500' below the Dundee top.

8. Describe typical cement program for long string. (continued)

The hole is drilled down to the top of the production zone, circulated and cleaned up. A caliper log is run and determination is made as to where to place centralizers and what cement volume is required to bring the cement top to 2000' from the surface. Depending on the condition of the hole, 10-20% excess cement over computed volume is used.

The casing is then run by a casing crew using power tongs. The bottom of the hole is tagged with the casing and the casing is then picked up two feet. After the casing has been landed, circulation is broken by pumping down casing and getting returns to surface.

A fresh water pad (50 barrels) is pumped ahead of the cement and the cement is pumped in. When the cement reaches the bottom of the casing, the pumping rate is slowed down so as not to exceed 2-1/2 barrels/minute. The cement is displaced with water and drilling fluid, leaving 20-30 feet of cement in the casing.

The well is shut in (WOC) and allowed to set 48 hours. The hole is then nippled up to drill out below the casing. After nippling up, the hole is run in with a drill pipe and top of cement tagged, drilled up to casing seat, and pressure tested to a minimum of 500 psig.

If the test is approved, drilling is continued to total depth. After the hole has been drilled to total depth and cleaned up, logs are run on the hole. Almost all of our Sylvania wells are open-hole completion.

Generally, the wells are "in gage," and no major problems have been encountered in the completion of our brine wells. There have been very few changes in the cement program over the years, except for type of cements used and/or the method of cement placement. We prefer the "slo-flo" technique of cementing rather than "turbulent flow," the merits of each being debatable. Naturally, we rely on our Dowell Division for vendor technology in this field.

Karl, I am sorry for the delay in getting this information to you. If you have additional questions or comments, please give me a call.

Sincerely,

Dick DeLine

D. Dick DeLine
Manufacturing Manager
(517)636-0150

lej

Enclosures (9)

cc: (Letter only) Senator Levin, B. G. Caldwell, Dr. H. Tanner, Dr. M. Reizen, R. Ellison